WALSHIRE LABS

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47 C.F.R. Part 15 FCC Rules, Subpart C
&
Industry Canada RSS-GEN Issue 3 & RSS-210 Issue 8
Test Results for the

UgMO™ Technologies

Augusta Irrigation Controller Repeater Unit

Equipment:	Augusta Repeater
Client:	Jabil Circuit, Inc. on behalf of Green Badge LLC D/B/A UgMO Technologies
Address:	10800 Roosevelt Boulevard St. Petersburg, FL 33716

Test Report Number: FCCIR-UGMO-02-09-12A
Date: September 7, 2012
Total Number of Pages: 78

NVLAP LAP Code: 200125-0
FCC Test Site Registration Number: 830450
Industry Canada Site Number 7868A-1

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1 IDENTIFICATION SUMMARY

1.1 Test Report

Test Report Number:	FCCIR-UGMO-02-09-12A
Test Report Date:	September 7, 2012

Report written and approved by:

Date	Name	Signature
September 7, 2012	Peter J. Walsh, NCE	Peter J. Walsh

1.2 Testing Laboratory

Walshire Labs, LLC
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1.3 Limits and Reservations

The test results in this report apply only to the particular Device Under Test (DUT) and component Implementations Under Test (IUTs) declared in this test report. The results and associated conclusions apply only to the DUT while operating in the configuration and modes described herein. The test data contained herein is intended to be used by a TCB for the purpose of achieving FCC Part 15 and Industry Canada RSS-210 Issue 8 certification of the DUT.

The test report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the federal government.

1.4 Client Information

Name:	Jabil Circuit, Inc. on behalf of Green Badge LLC dba UgMO Technologies
Street:	10800 Roosevelt Blvd.
City:	St. Petersburg
State:	FL
Zip Code	33716
Country:	USA
Phone:	(727) 803-5926
Contact Person:	Tom Snyder
Phone:	(727) 803-5926
Email:	Tom_Synder@jabil.com

1.5 Dates

Date of commission:	February 7, 2012
Date of receipt of DUT:	February 7, 2012
Date of test completion:	September 7, 2012

1.6 Device Under Test (DUT)

Name:	Repeater
Version:	Model UG1000R
Serial Number:	None (Engineering Prototype)
Antenna Type:	PCB Trace
Nominal Gain:	-2.0 dBi
Modulation Type:	FSK
Bit Rate:	38.4 kBaud
AC Power Adapters:	Jasper Electronics Model CM005-1-M1405G Golden Regent Electronics Industrial / GOLD Model APS-03C5-2-UL

2 GENERAL INFORMATION

2.1 Product Description

The Repeater is a component of the UgMO Technologies advanced irrigation system that employs a radio operating in the 902-928 MHz ISM band. The radio serves as a wireless link to other components in the system including a base station unit and a bridge unit which will be certified separately. The Repeater also employs a 433.92 MHz receiver to receive information from previously certified moisture sensors.

2.2 Interface Cable Details

No interface cables were used as the DUT doesn't have any user accessible interfaces.

2.3 Peripheral Devices

No test support devices were used in the test set-up. A PC was used to invoke test modes. However, the PC was disconnected prior to making any measurements.

2.4 Test Methodology

Testing was performed according to ANSI C63.4-2003, the procedure referenced by Part 15, FCC Rules along with DA 00-705, "Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems. Radiated emissions tests were performed at an antenna to EUT distance of 3 meters.

2.5 Test Facility

The 3-meter semi-anechoic test chamber and measurement facility used to collect the radiated and conducted data is located at 8545 126th Avenue N., Largo FL 33773. This site is NVLAP Accredited (200125-0). The site has been registered with the FCC under registration number 830450. The site has also been registered with Industry Canada, 2146A-1.

2.6 Deviations

No deviations were exercised during the course of the testing.

3 SYSTEM TEST CONFIGURATION

3.1 Justification

The DUT is a wall mounted device. Consistent with guidance in ANSI C63.4-2003, the DUT was tested in a table top configuration though to facilitate its proper mounting and orientation it was fastened to a small sheet of plywood secured to the table. Radiated and ac mains conducted emissions tests were performed in that manner using the DUT's internal antenna. Conducted tests were also performed using a second radio board modified by replacing the internal antenna connection with a short coaxial cable.

Various test modes were used to simulate the DUT's normal modes of operation in the absence of companion equipment. A continuous transmission test mode was used for all tests save for those which entailed conformance testing relative to frequency hopping requirements and receiver spurious emissions. The continuous test mode modulated the carrier frequency using a pseudo random binary sequence. A frequency hopping test mode was used for those tests which represented a frequency hopping sequence used in normal operation. A receiver test mode was used to measure receiver spurious emissions and also to assess the DUT's emissions with the radio off for compliance with Part 15 Subpart B radiated emissions requirements.

Tests were performed on three channels. The power settings were set as shown in the table below.

Table 3.1-1 – Power Setting by Channel Number

Channel Number	Center Frequency (MHz)	Power Setting
0	903.053	0xf0
24	915.036	0xf0
49	927.492	0xf0

3.2 Special Accessories

None were supplied.

3.3 Equipment Modifications

No modifications were needed to achieve compliance.

Signature:	Peter J. Walsh	Date:	September 7, 2012
Typed/Printed Name:	Peter J. Walsh		
Position:	Regulatory Lab Manager		

If modifications were needed to achieve compliance, the client shall acknowledge these by signing below.

Signature:		Date:	
Typed/Printed Name:			
Position:			

4 CONDUCTED EMISSIONS DATA

References: 47 C.F.R. § 15.207 (a)
RSSGEN § 7.2.4

(a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 µH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

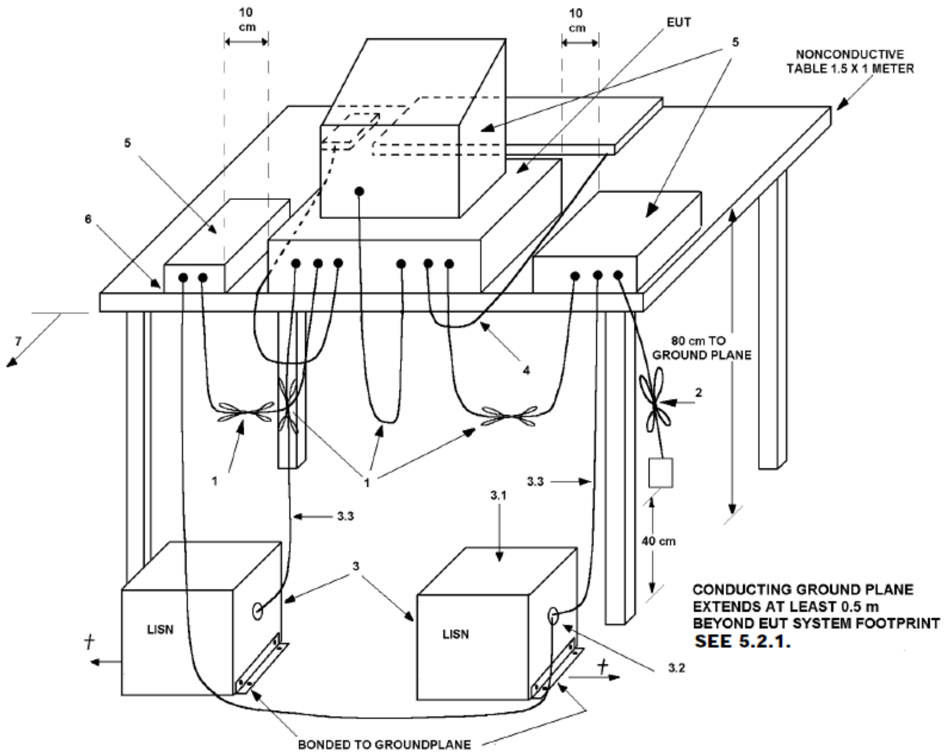
Table 4-1

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-peak	Average
0.15-0.5	66 to 56 *	56 to 46 *
0.5-5	56	46
5-30	60	50

* Decreases with the logarithm of the frequency.

4.1 Test Procedure

The test is performed in accordance with ANSI C63.4-2003 § 7. The test setup is consistent with ANSI C63.4-2003 Figure 10a as shown below. The test is performed in a semi-anechoic chamber. As such, the optional vertical conducting plane is not used.



LEGEND:

1) Interconnecting cables that hang closer than 40 cm to the groundplane shall be folded back and forth in the center forming a bundle 30 to 40 cm long (see 6.1.4 and 11.2.4).
2) I/O cables that are not connected to a peripheral shall be bundled in the center. The end of the cable may be terminated, if required, using the correct terminating impedance. The overall length shall not exceed 1 m (see 6.1.4).
3) EUT connected to one LISN. Unused LISN measuring port connectors shall be terminated in 50 Ω. LISN can be placed on top of, or immediately beneath, reference groundplane (see 5.2.3 and 7.2.1).
   3.1) All other equipment powered from additional LISN(s).
   3.2) Multiple outlet strip can be used for multiple power cords of non-EUT equipment.
   3.3) LISN at least 80 cm from nearest part of EUT chassis.
4) Cables of hand-operated devices, such as keyboards, mice, etc., shall be placed as for normal use (See 6.2.1.3 and 11.2.4).
5) Non-EUT components of EUT system being tested (see also Figure 13).
6) Rear of EUT, including peripherals, shall all be aligned and flush with rear of tabletop (see 6.2.1.1 and 6.2.1.2).
7) Rear of tabletop shall be 40 cm removed from a vertical conducting plane that is bonded to the groundplane (see 5.2.2 for options).

Figure 10a—Test arrangement for conducted emissions

Conducted emissions measurements are first made using a peak detector and average detector simultaneously. The receiver then performs the final measurements using a quasi-peak detector for comparison with the quasi-peak limit and an average detector for comparison with the average limit.

4.2 Measured Data

Compliance Verdict: PASS

Figures 4.2-1 and 4.2-1 show composite graphs of the line and neutral conducted emissions as measured with a nominal line voltage of 120 V and line frequency of 60 Hz with the Jasper Electronics and GOLD ac power adapters respectively. The figures show the emission levels using the peak detector (blue trace) and the average detector (green trace).

Tables 4.2-1 and 4.2-2 show the final measured results with the Jasper Electronics ac power adapter in a tabular data format using the quasi-peak and average detectors. Tables 4.2-3 and 4.2-4 show the final measured results with the GOLD ac power adapter.

These tests were performed with the DUT's radio placed in the continuous transmission test mode.

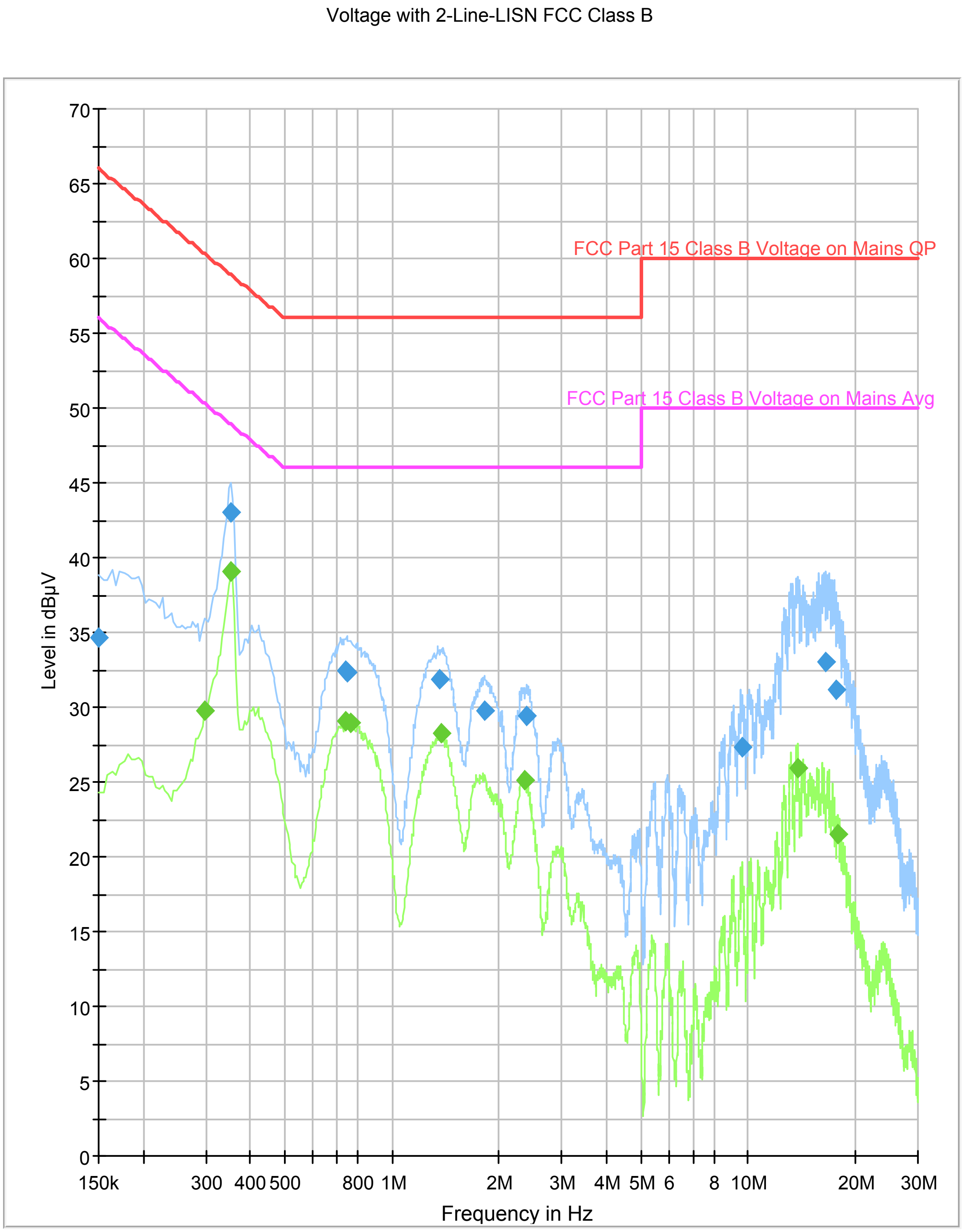


Figure 4.2-1 – FCC Part 15 Class B Conducted Emissions Plot with the Jasper Electronics Power Adapter

Voltage with 2-Line-LISN FCC Class B

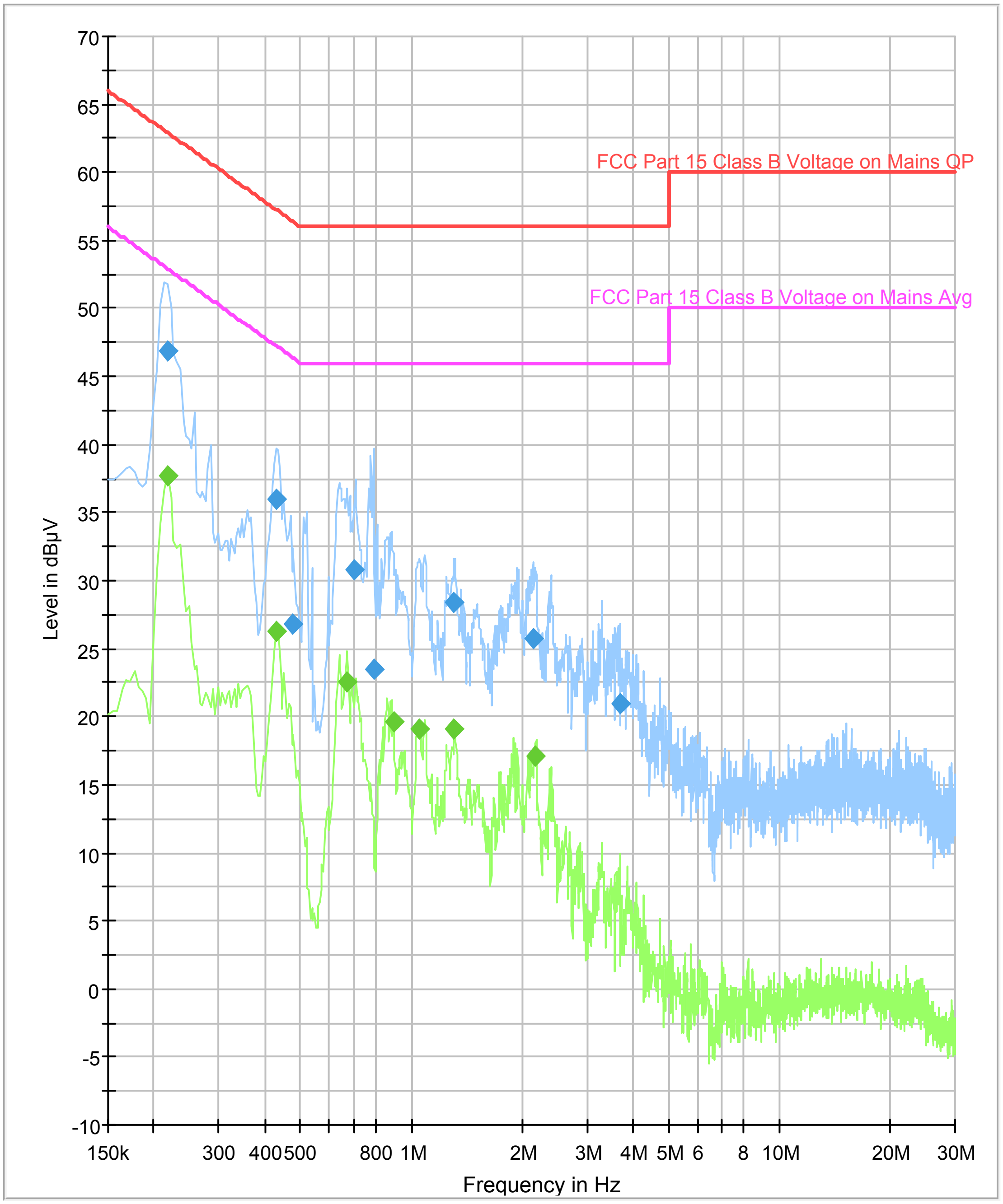


Figure 4.2-2 – FCC Part 15 Class B Conducted Emissions Plot with the GOLD Power Adapter

Table 4.2-1 - Final Quasi-peak Detector Results with the Jasper Electronics Power Adapter

Frequency (MHz)	QuasiPeak (dBµV)	Line	CF* (dB)	Margin (dB)	Limit (dBµV)
0.150000	34.7	N	0.1	31.3	66.0
0.352500	43.0	N	0.1	15.9	58.9
0.739500	32.5	N	0.2	23.5	56.0
0.748500	32.4	N	0.2	23.6	56.0
1.360500	31.9	N	0.2	24.1	56.0
1.828500	29.8	N	0.3	26.2	56.0
2.400000	29.4	N	0.3	26.6	56.0
9.582000	27.4	N	0.8	32.6	60.0
16.570500	33.0	L1	1.5	27.0	60.0
17.691000	31.2	L1	1.6	28.8	60.0

Table 4.2-2 - Final Average Detector Results with the Jasper Electronics Power Adapter

Frequency (MHz)	Average (dBµV)	Line	CF* (dB)	Margin (dB)	Limit (dBµV)
0.298500	29.8	N	0.1	20.5	50.3
0.352500	39.0	N	0.1	9.9	48.9
0.739500	29.1	N	0.2	16.9	46.0
0.766500	29.0	N	0.2	17.0	46.0
1.369500	28.2	N	0.2	17.8	46.0
2.350500	25.2	N	0.3	20.8	46.0
13.780500	25.9	N	1.1	24.1	50.0
17.889000	21.5	N	1.3	28.5	50.0

* CF is the LISN correction factor plus cable loss.

Minimum Margin: **9.9 dBµV**

Measurement Uncertainty: +/- 3.59 dB

Test Personnel:

Date	Name	Signature
September 4, 2012	Peter J. Walsh, NCE	Peter J. Walsh

Table 4.2-3 - Final Quasi-peak Detector Results with the GOLD Power Adapter

Frequency (MHz)	QuasiPeak (dBµV)	Line	CF* (dB)	Margin (dB)	Limit (dBµV)
0.217500	46.9	L1	0.1	16.0	62.9
0.429000	36.0	L1	0.1	21.3	57.3
0.474000	26.9	L1	0.1	29.5	56.4
0.699000	30.8	L1	0.2	25.2	56.0
0.789000	23.5	L1	0.2	32.5	56.0
1.302000	28.4	L1	0.3	27.6	56.0
2.148000	25.7	L1	0.3	30.3	56.0
3.687000	20.9	N	0.5	35.1	56.0

Table 4.2-4 - Final Average Detector Results with the GOLD Power Adapter

Frequency (MHz)	Average (dBµV)	Line	CF* (dB)	Margin (dB)	Limit (dBµV)
0.217500	37.7	L1	0.1	15.2	52.9
0.429000	26.3	L1	0.1	21.0	47.3
0.667500	22.6	L1	0.2	23.4	46.0
0.892500	19.6	L1	0.2	26.4	46.0
1.054500	19.1	L1	0.2	26.9	46.0
1.297500	19.1	L1	0.3	26.9	46.0
2.170500	17.1	L1	0.3	28.9	46.0

* CF is the LISN correction factor plus cable loss.

Minimum Margin: **15.2 dBµV**

Measurement Uncertainty: +/- 3.59 dB

Test Personnel:

September 7, 2012	Peter J. Walsh, NCE	Peter J. Walsh
Date	Name	Signature

4.3 Conducted Emissions Test Instrumentation

Type	Manufacturer/ Model No.	Serial Number	Calibration Due Date
EMI Receiver	Rohde & Schwarz ESCS 30	825788/002	11/03/2012
LISN	Rohde & Schwarz ESH3-Z5	840730/005	09/04/2014

Calibration and Traceability: All measuring and test equipment are calibrated and are traceable to the National Institute for Standards and Technology (NIST) and Methods.

4.4 Conducted Emissions Photographs

Photo 4.4-1 - Front View of the Conducted Emissions Test Set-up

Photo 4.4-2 - Rear View of the Conducted Emissions Test Set-up

5 RADIATED EMISSIONS DATA

References: 47 C.F.R. § 15.209
RSS-210 § 2.2
RSSGEN § 6.1

(a) Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Table 5-1

Frequency of Emission (MHz)	Field Strength (3 m) (microvolts/meter)	Field Strength (3 m) (dBµV/m)
0.009 – 0.490	2400/F (kHz) @ 300 m	300
0.490 – 1.705	24000/F (kHz) @ 30 m	30
1.705 – 30.0	30 @ 30 m	30
30 - 88	100**	40.0
88 - 216	150**	43.5
216 - 960	200**	46.0
Above 960	500	54.0

*** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.*

The field strength limits for frequencies below 30 MHz were calculated for a measurement distance of 3 m using the prescribed 40 dB/decade correction factor as shown in Figure 5-1.

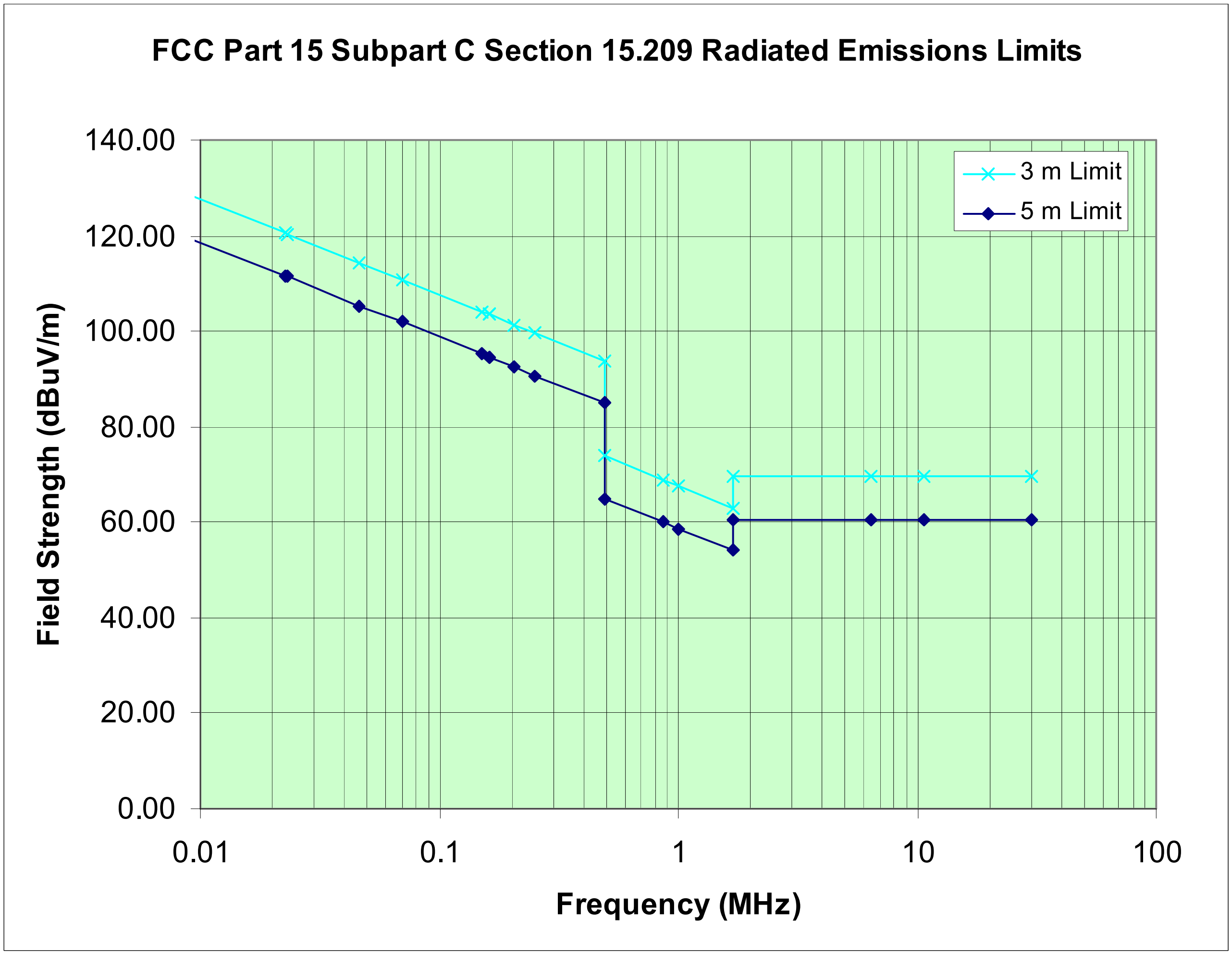


Figure 5-1 – Adjusted Field Strength Limits

References: 47 C.F.R. § 15.205
RSS-210 § 2.2

(a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

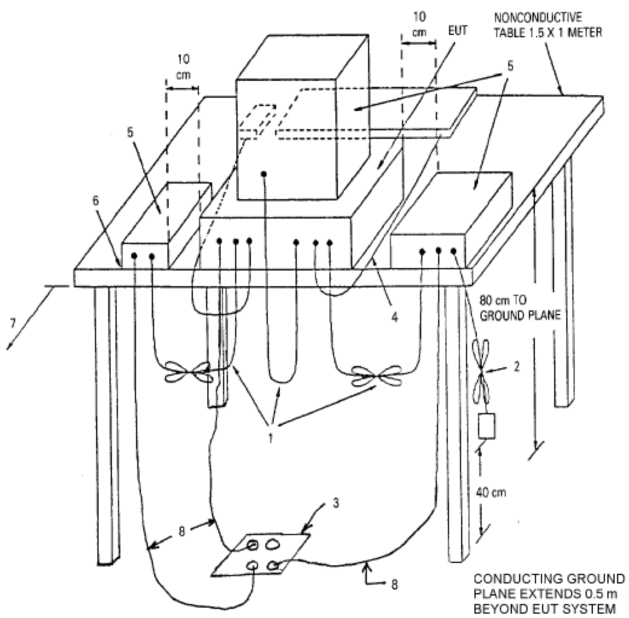
Table 5-2

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
[1]0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	([2])
13.36 - 13.41			

(b) Except as provided in paragraphs (d) and (e), the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section 15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in Section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in Section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in Section 15.35 apply to these measurements.

5.1 Test Procedure

The test is performed in accordance with ANSI C63.4-2003 § 8. The test setup is consistent with ANSI C63.4-2003 Figure 11a below. The test is performed in a semi-anechoic chamber.



LEGEND:

1) Interconnecting cables that hang closer than 40 cm to the groundplane shall be folded back and forth in the center, forming a bundle 30 to 40 cm long (see 6.1.4 and 11.2.4).
2) I/O cables that are not connected to a peripheral shall be bundled in the center. The end of the cable may be terminated if required using the correct terminating impedance. The total length shall not exceed 1 m (see 6.1.4).
3) If LISNs are kept in the test setup for radiated emissions, it is preferred that they be installed under the groundplane with the receptacle flush with the groundplane (see 6.1.4).
4) Cables of hand-operated devices, such as keyboards, mice, etc., shall be placed as for normal use (see 6.2.1.3 and 11.2.4).
5) Non-EUT components of EUT system being tested (see also Figure 13).
6) Rear of EUT, including peripherals, shall all be aligned and flush with rear of tabletop (see 6.2.1.1 and 6.2.1.2).
7) No vertical conducting plane used (see 5.2.2).
8) Power cords drape to the floor and are routed over to receptacle (see 6.1.4).

Figure 11a—Test arrangement for radiated emissions tabletop equipment

The following data lists the significant emission frequencies, amplitude levels (including cable correction and antenna factors), plus the limit. The frequency range investigated was 14.74 MHz to 10 GHz. The highest frequency to which the DUT must be measured is 9.28 GHz as this is ten times the highest operating frequency of the DUT. The lowest frequency tested (14.74 MHz) was determined by a crystal frequency of 14.74 MHz used in the transceiver.

5.2 Test Data

Compliance Verdict: PASS

There were no emissions within 20 dB of the FCC Part 15 and RSS-GEN limits over the frequency range of 14.74 – 30 MHz.

Figures 5.2-1 through 5.2-3 show peak detector exploratory scans with the radio operating on channels 24, 0, and 49 respectively. These show graphs of the radiated emissions levels from 30 to 1000 MHz measured with a peak detector in both vertical (red trace) and horizontal (blue trace) antenna polarities at turntable angles between 0 and 360 degrees and antenna heights of 100 cm, 250 cm and 400 cm. Operation on channel 24 resulted in the highest overall field strength.

Figures 5.2.4 and 5.2.5 show the final composite preview scan graphs of the radiated emissions levels from 30 to 1000 MHz measured with a peak detector in both vertical (red trace) and horizontal (blue trace) antenna polarities at turntable angles of 0, 90, 180, and 270 degrees and antenna heights of 100 cm, 250 cm and 400 cm. In the 30 to 1000 MHz frequency range, the final measurement detector was quasi-peak; the measurement bandwidth was 120 kHz. The final measurements denoted by the diamonds were taken with the turntable angle, antenna elevation and polarity set to maximize the received levels. Figure 5.2.4 shows the DUT's emissions with the transmitter on. Figure 5.2.5 shows the DUT's emissions with the transmitter off and therefore is a measure of receiver spurious emissions in accordance with RSSGEN Clause 6.1.

Tables 5.2-1 – 5.2-4 show the highest measured results within 20 dB of the limit.

For measurements taken above 1 GHz, the final measurement detectors were peak and average. The measurement bandwidth was 1 MHz. Figure 5.2-9 shows the maximum (peak hold) radiated emissions from 1 to 10 GHz. This plot includes measurements at all turntable angles and an antenna heights set to maximize emissions.

Additional radiated emissions measurements were made over a frequency range which included the 902 MHz to 928 MHz operating band as well as frequencies above this band to ensure compliance with the restricted band limits for operation on Channels 0, 24, and 49.

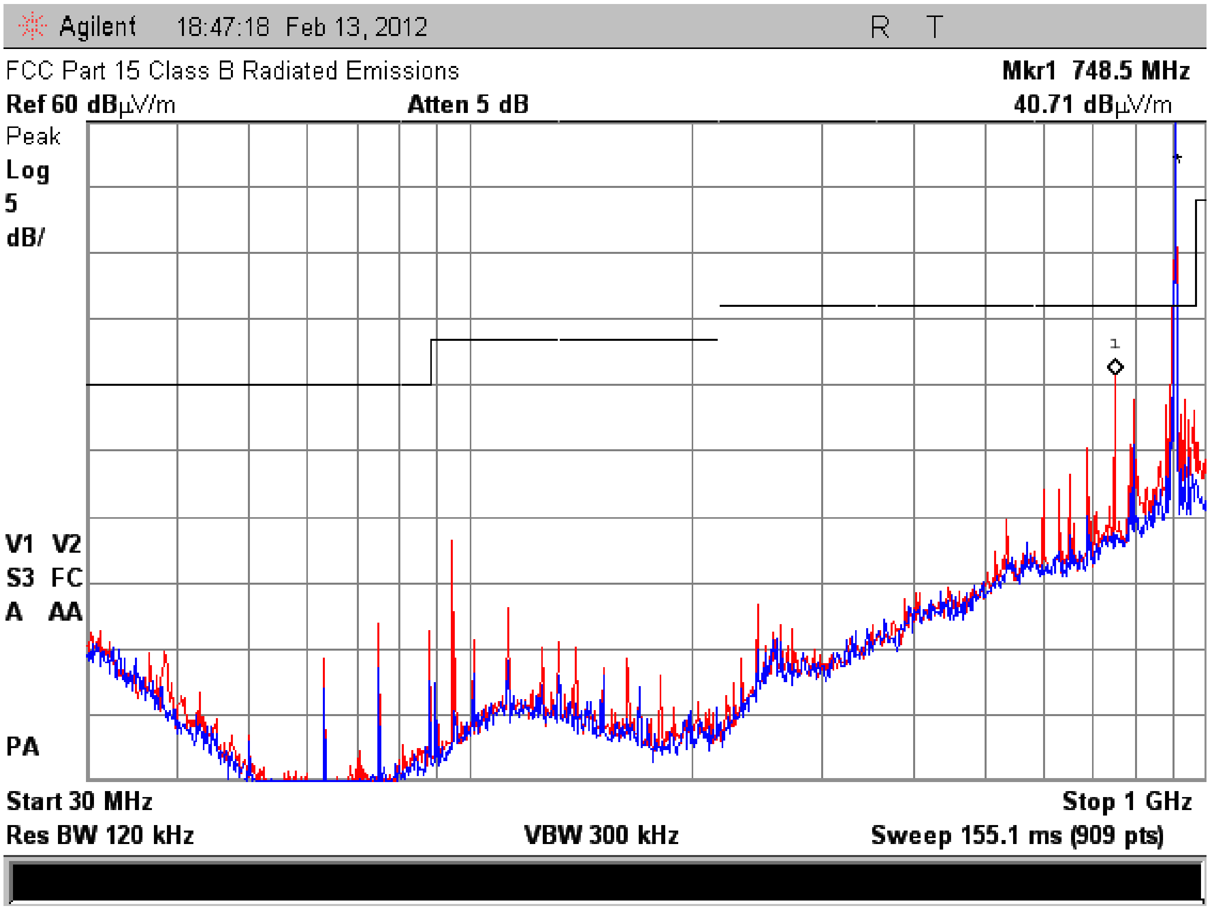


Figure 5.2-1 – Radiated Emissions Peak Detector Plot for the 30 – 1000 MHz Band Channel 24

Notes:

For this test, the DUT was operating on its mid-band channel, Channel 24, in the continuous transmission test mode. The red trace was with vertical polarity. The blue trace was with horizontal polarity. The only emission above the general radiated emissions limit was the permitted emission in the 902 MHz to 928 MHz operating band.

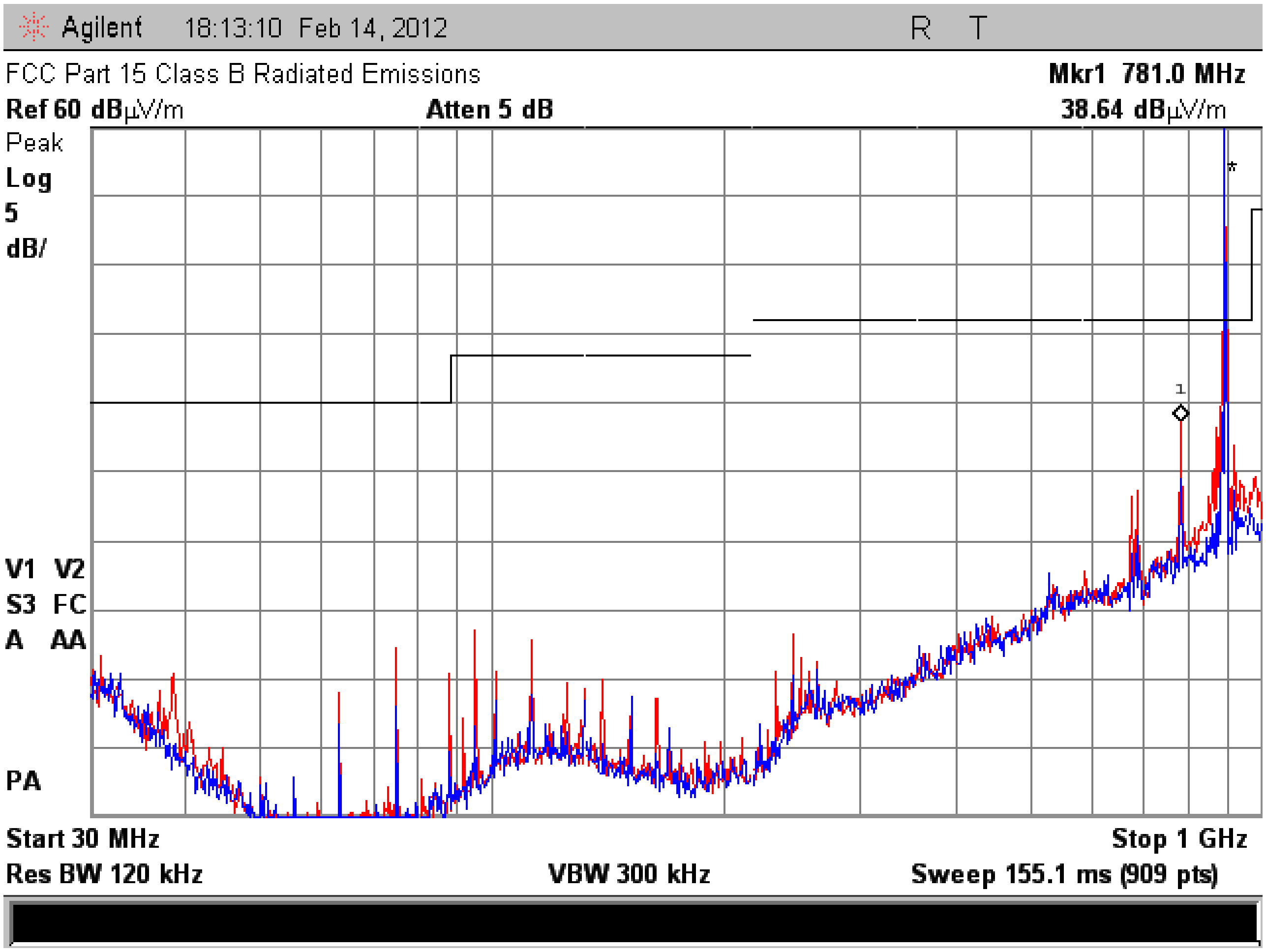


Figure 5.2-2 – Radiated Emissions Peak Detector Plot for the 30 – 1000 MHz Band Channel 0

Notes:

For this test, the DUT was operating on its mid-band channel, Channel 0, in the continuous transmission test mode.

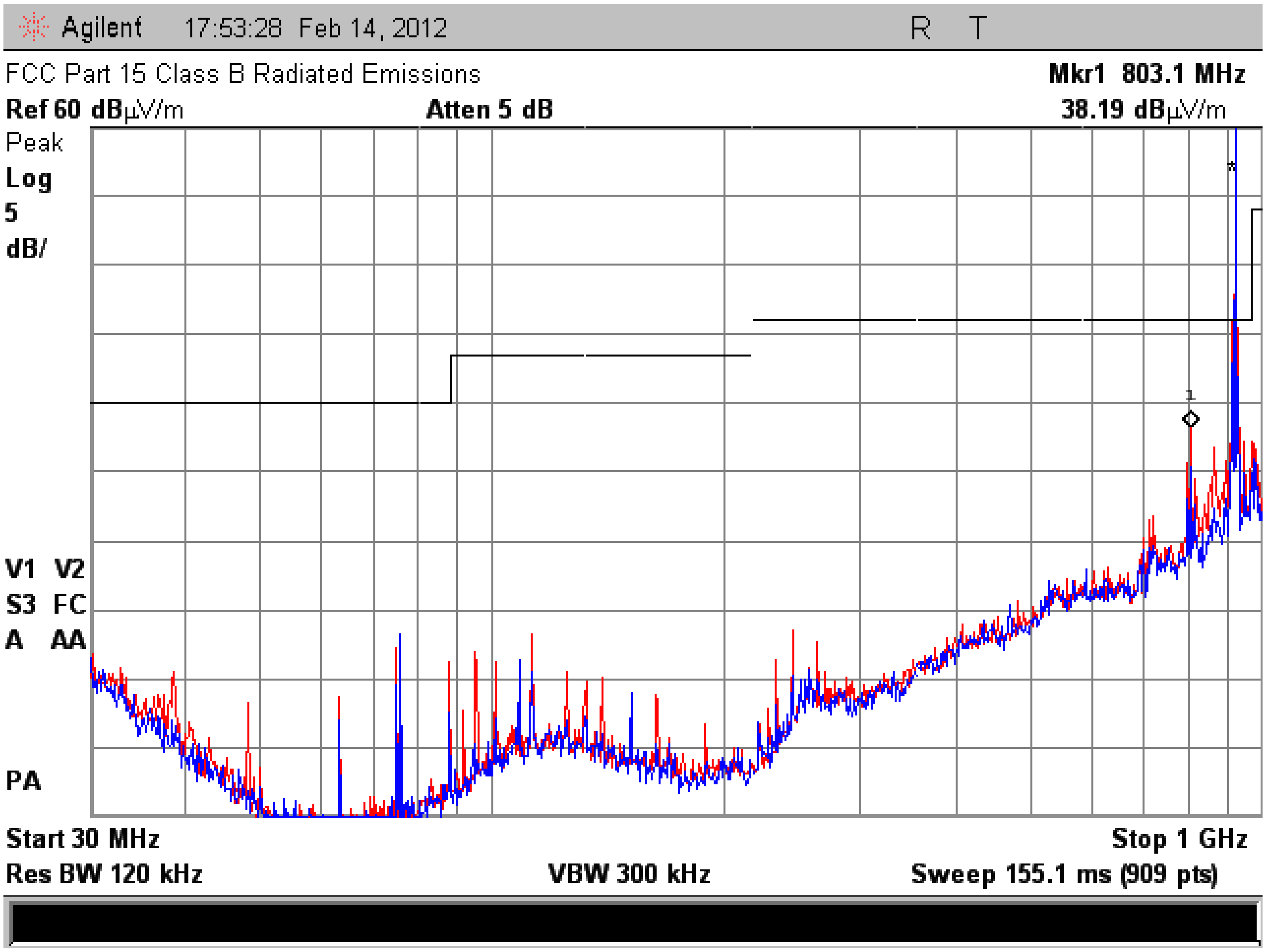


Figure 5.2-3 – Radiated Emissions Peak Detector Plot for the 30 – 1000 MHz Band Channel 49

Notes:

For this test, the DUT was operating on its mid-band channel, Channel 49, in the continuous transmission test mode.

FCC Class B 3m 30-1000 MHz Final Test

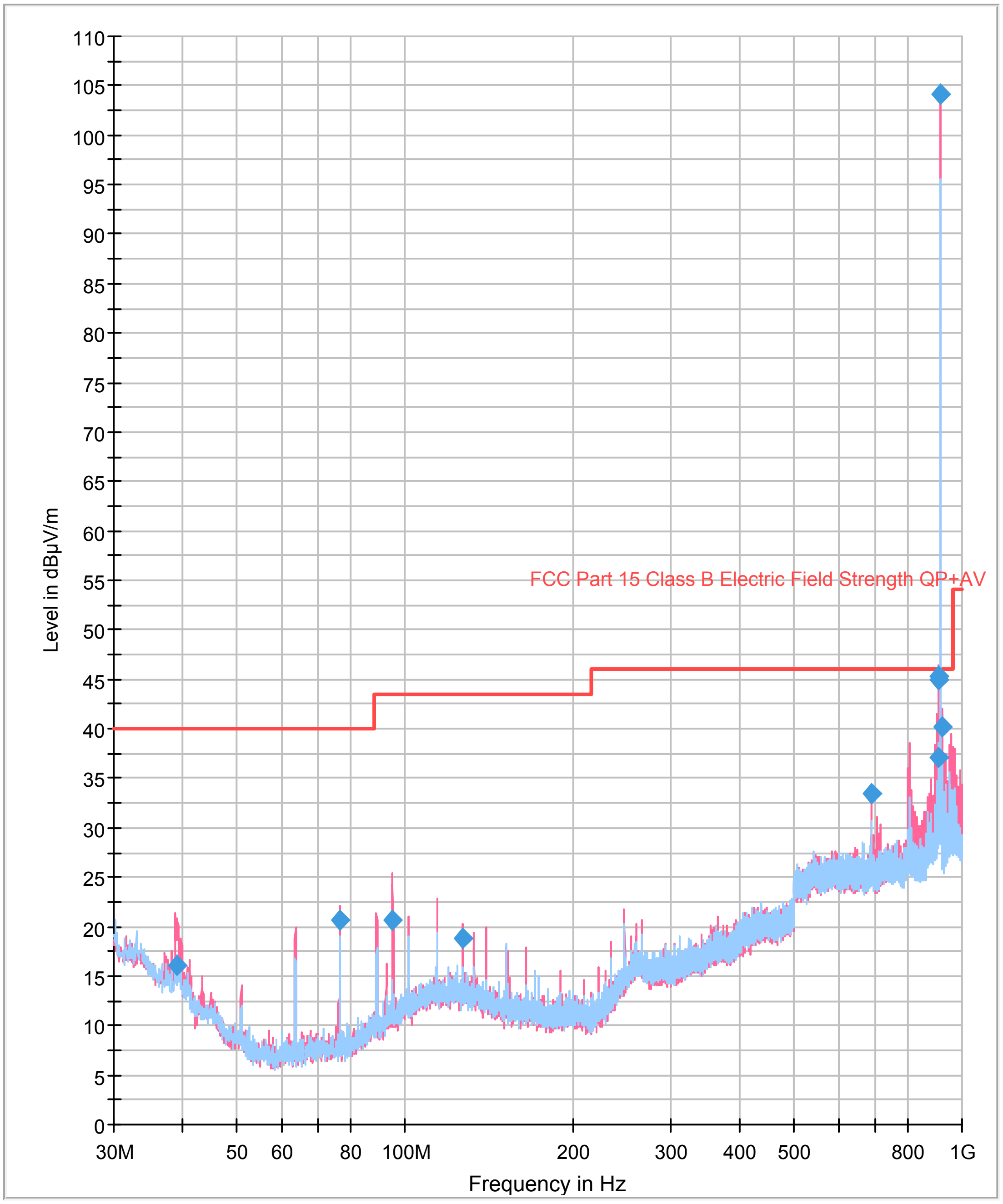


Figure 5.2-4 – Final Radiated Emissions Plot for the 30 – 1000 MHz Band

Notes: For this test, the DUT was operating on its mid-band channel, Channel 24, in the continuous transmission test mode. The red trace was with vertical polarity, peak detector. The blue trace was with horizontal polarity, peak detector.

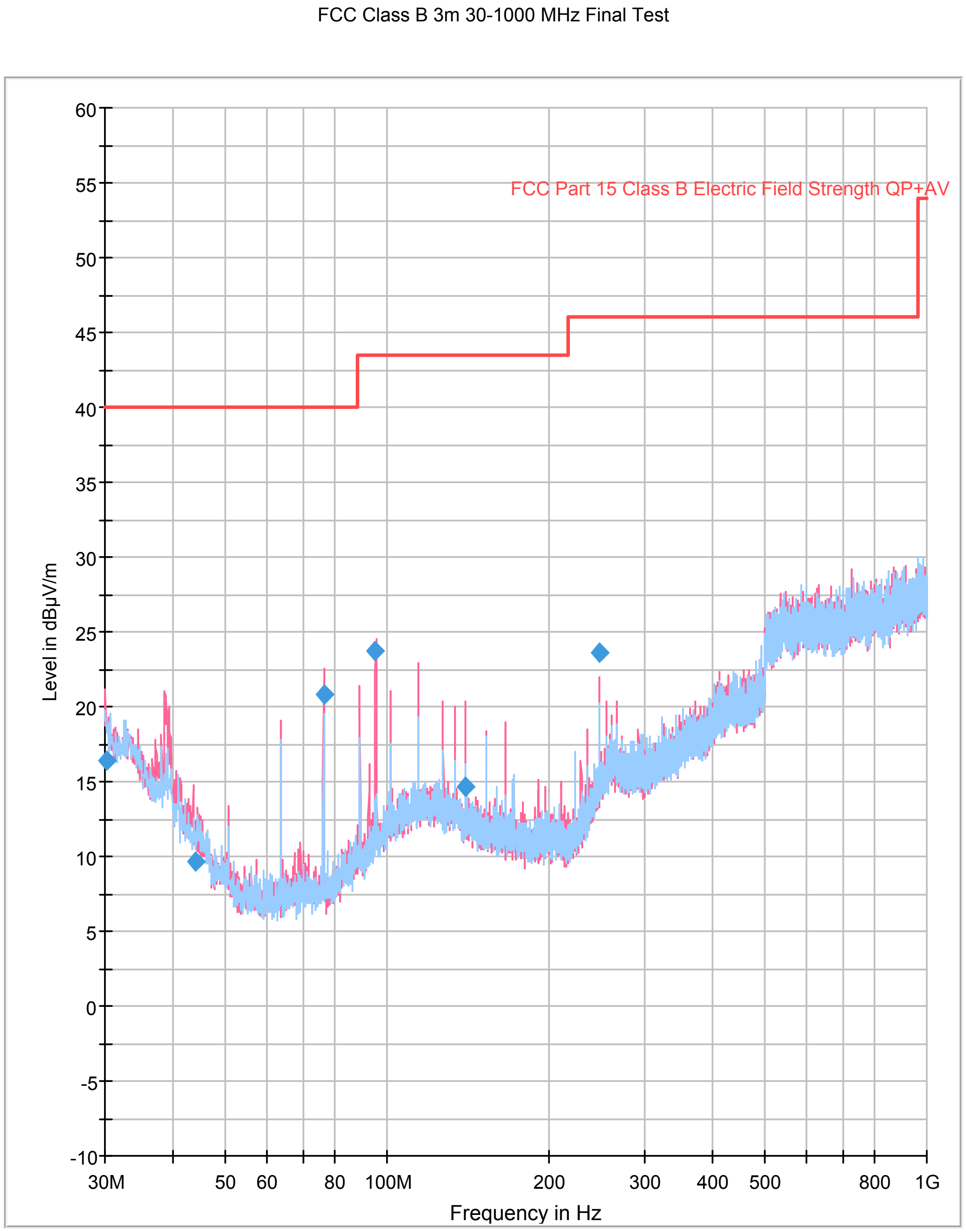


Figure 5.2-5 –Radiated Emissions Plot for the 30 – 1000 MHz Band in Receive Test Mode

Notes:
For this test, the DUT's transmitter was turned off. This test satisfied Industry Canada's receiver spurious emission requirements as well as FCC Part 15 Subpart B, Class B radiated emissions requirements for the DUT's digital circuitry.

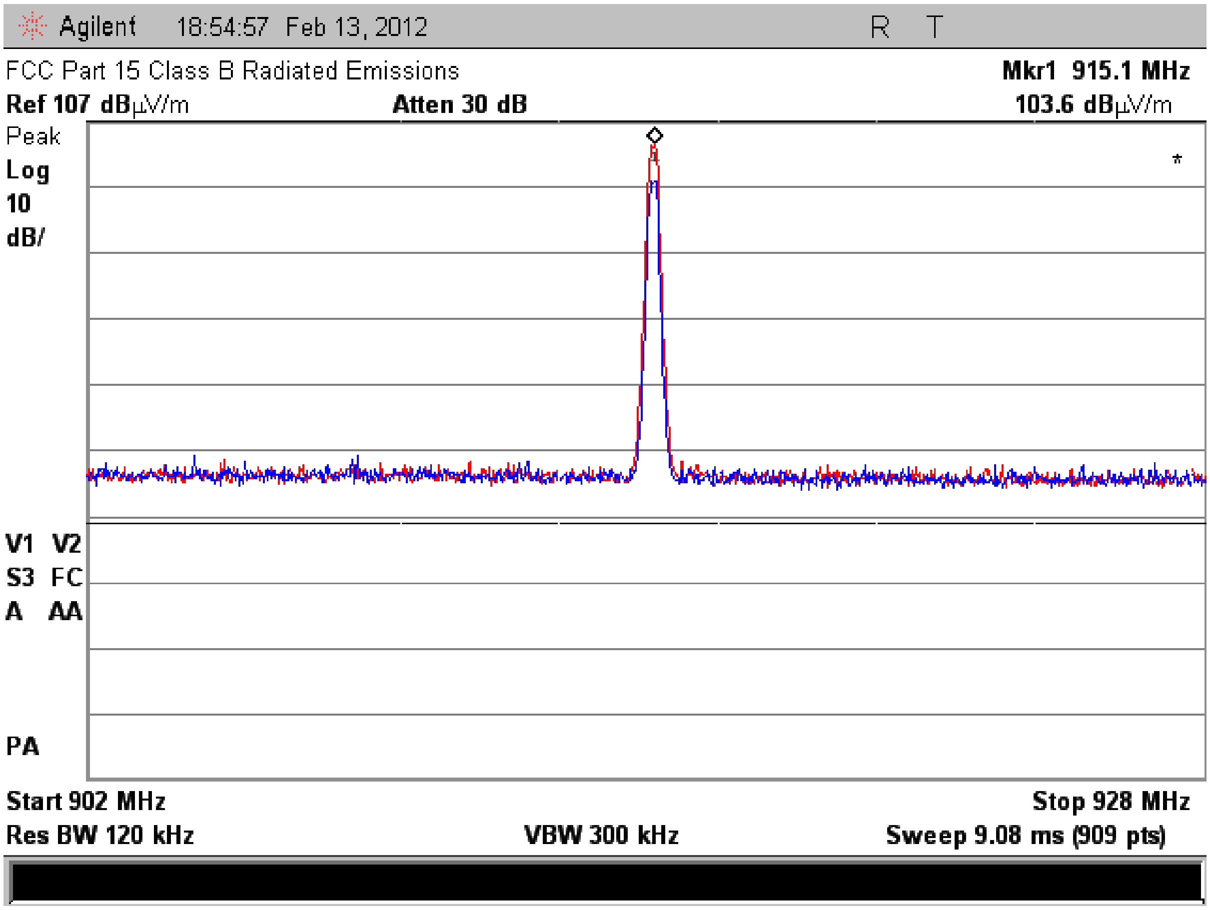


Figure 5.2-6 – Informative Peak Detector Field Strength Measurement of the Fundamental on Ch. 24

Notes:

The red trace was with vertical polarity. The blue trace was with horizontal polarity. The DUT was set to transmit in its continuous transmission test mode. The highest field strength was observed with vertical polarity. Also, operation on Channel 24 resulted in the highest overall field strength as compared to the other tested channels.

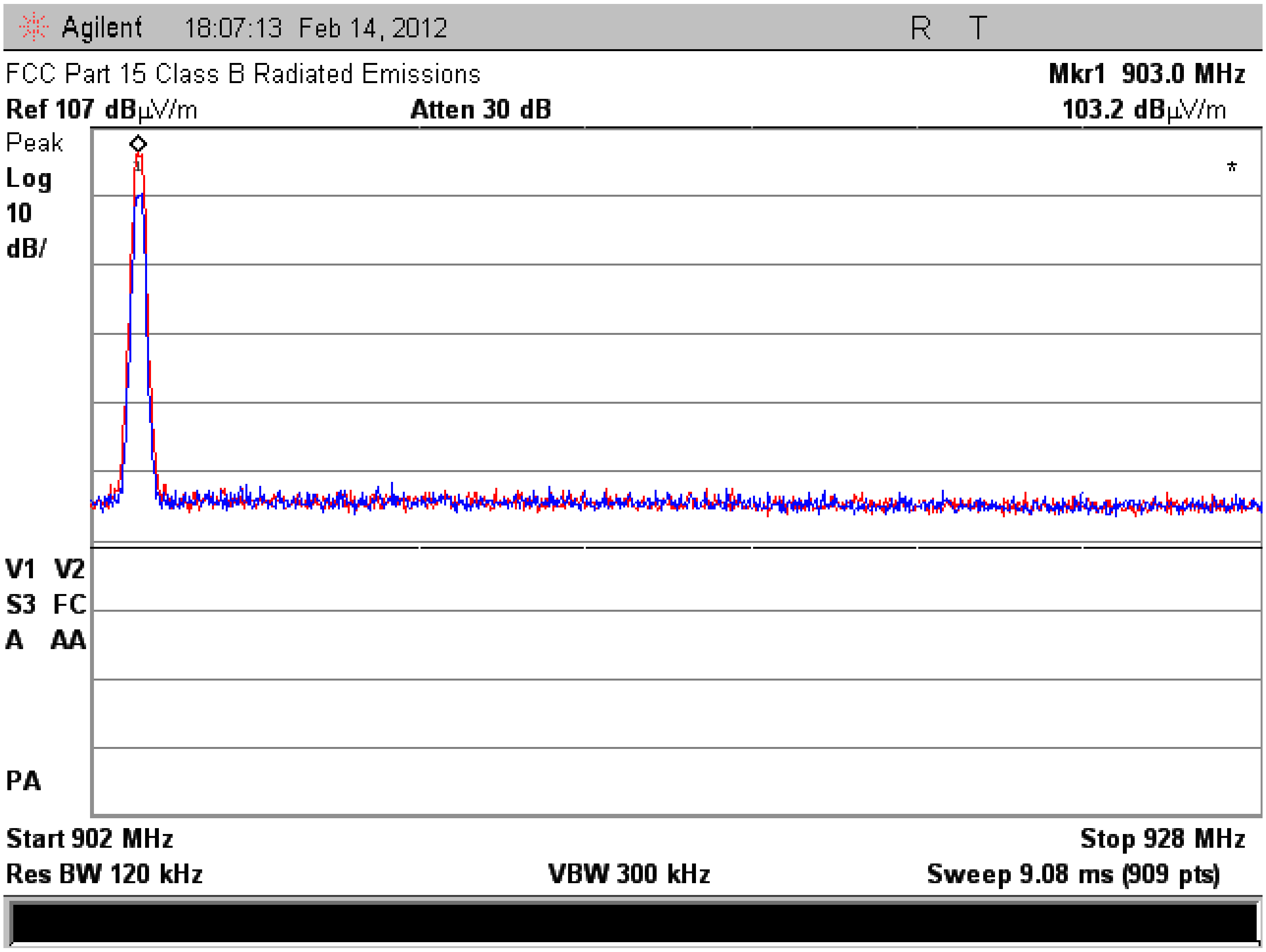


Figure 5.2-7 – Informative Peak Detector Field Strength Measurement of the Fundamental on Ch. 0

Notes:

The red trace was with vertical polarity. The blue trace was with horizontal polarity. The DUT was set to transmit in its continuous transmission test mode.

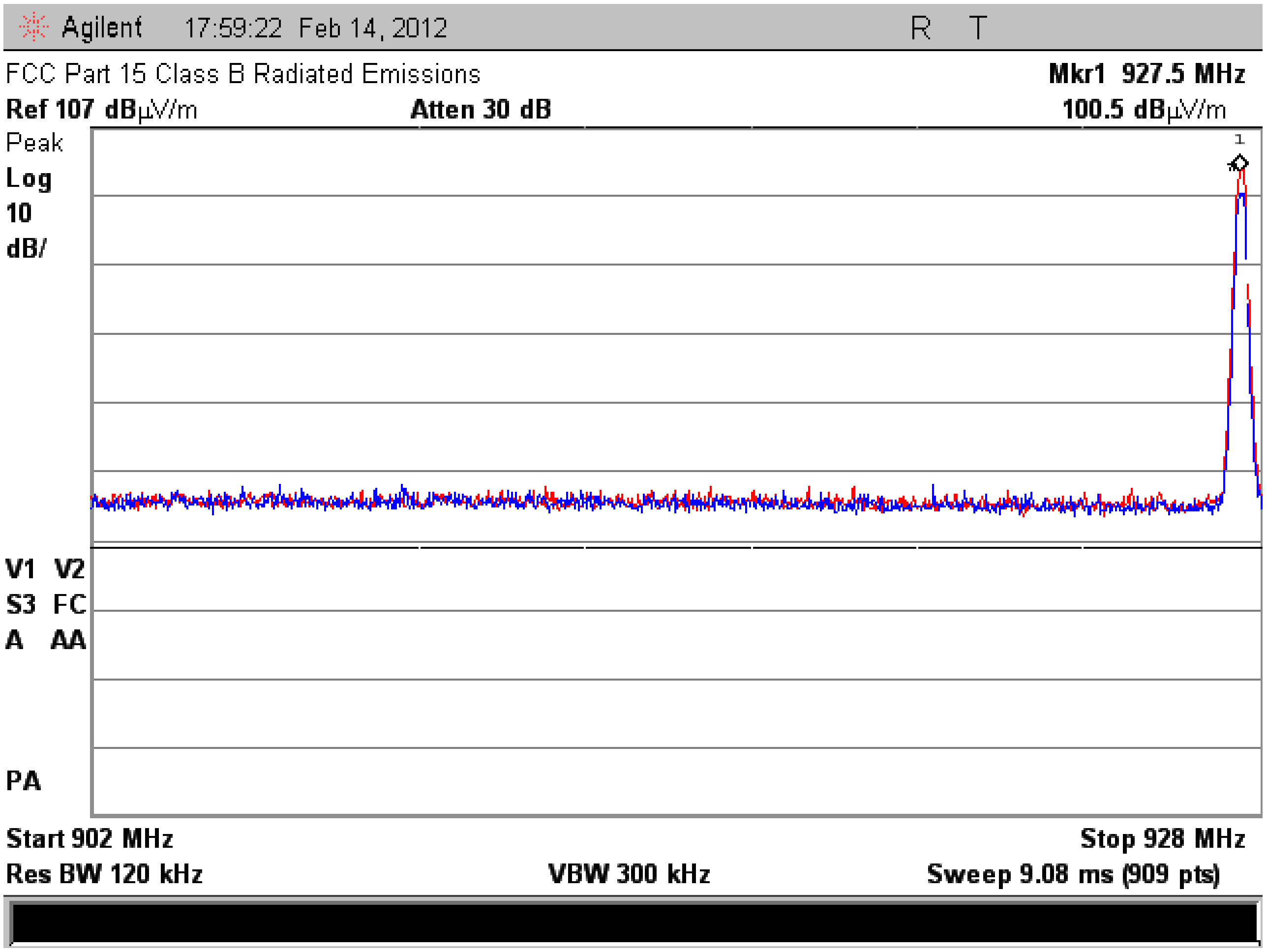


Figure 5.2-8 – Informative Peak Detector Field Strength Measurement of the Fundamental on Ch. 49

Notes:

The red trace was with vertical polarity. The blue trace was with horizontal polarity. The DUT was set to transmit in its continuous transmission test mode.

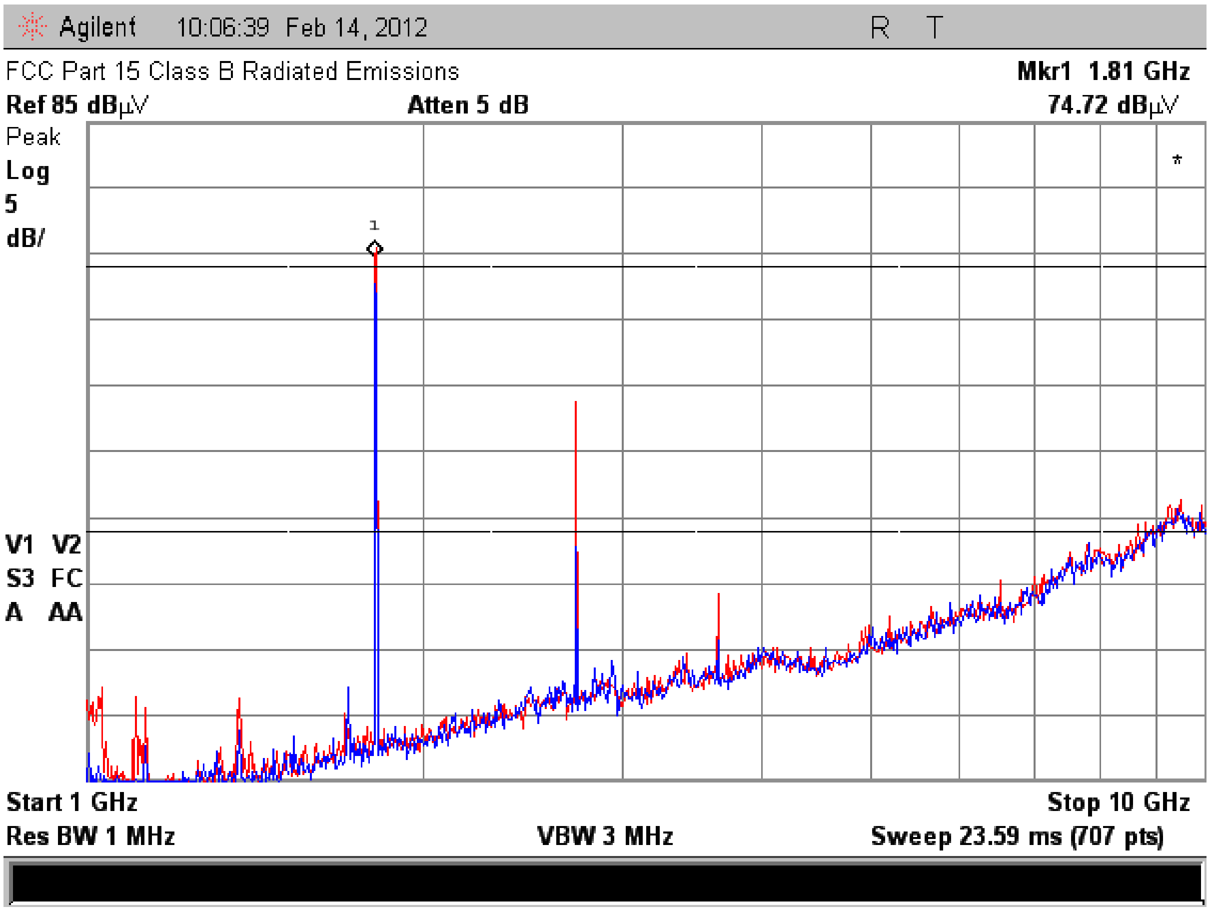


Figure 5.2-9 – Radiated Emissions 1 – 10 GHz (Peak Detector) Channel 24

Notes:

The red trace was with vertical polarity. The blue trace was with horizontal polarity. The DUT was set to transmit its continuous transmission test mode.

The frequency of the highest emission was 1.831 GHz; the second harmonic. Because this emission was greater than 20 dB down from the fundamental and it did *not* fall in a restricted band, it was judged to be acceptable.

The frequency of the second highest emission was 2.747 GHz; the third harmonic. This emission was greater than 20 dB down from the fundamental but it did fall in the 2690 MHz – 2900 MHz restricted band. The field strength level was below the peak limit but would have to be measured with the average detector relative to the average limit.

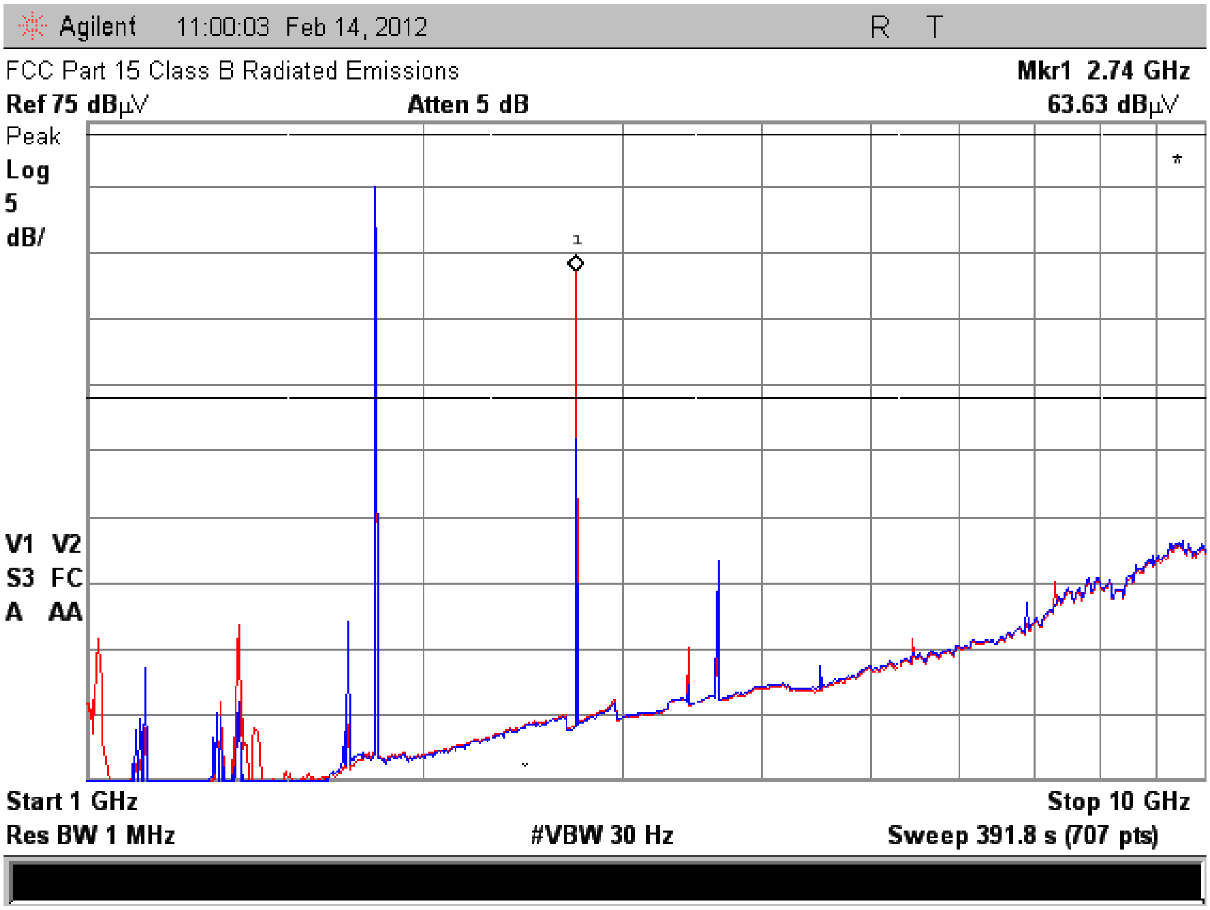


Figure 5.2-10 – Radiated Emissions 1 – 10 GHz (Average Detector) Channel 24

Notes:

The red trace was with vertical polarity. The blue trace was with horizontal polarity. The DUT was set to transmit its continuous transmission test mode.

The frequency of the highest emission was 1.831 GHz; the second harmonic. Because this emission was greater than 20 dB down from the fundamental and it did *not* fall in a restricted band, it was judged to be acceptable.

The frequency of the second highest emission was 2.747 GHz; the third harmonic. This emission was greater than 20 dB down from the fundamental but it did fall in the 2690 MHz – 2900 MHz restricted band. The field strength level when measured with the average detector was 63.6 dBµV/m. To determine if this emission was truly over the limit another measurement was made with a 1000 MHz high pass filter installed on the input of the preamplifier. This would allow for better sensitivity in the presence of the fundamental. Using this measurement technique this emission was below the average limit. The result of that test is shown in Figure 5.2-11.

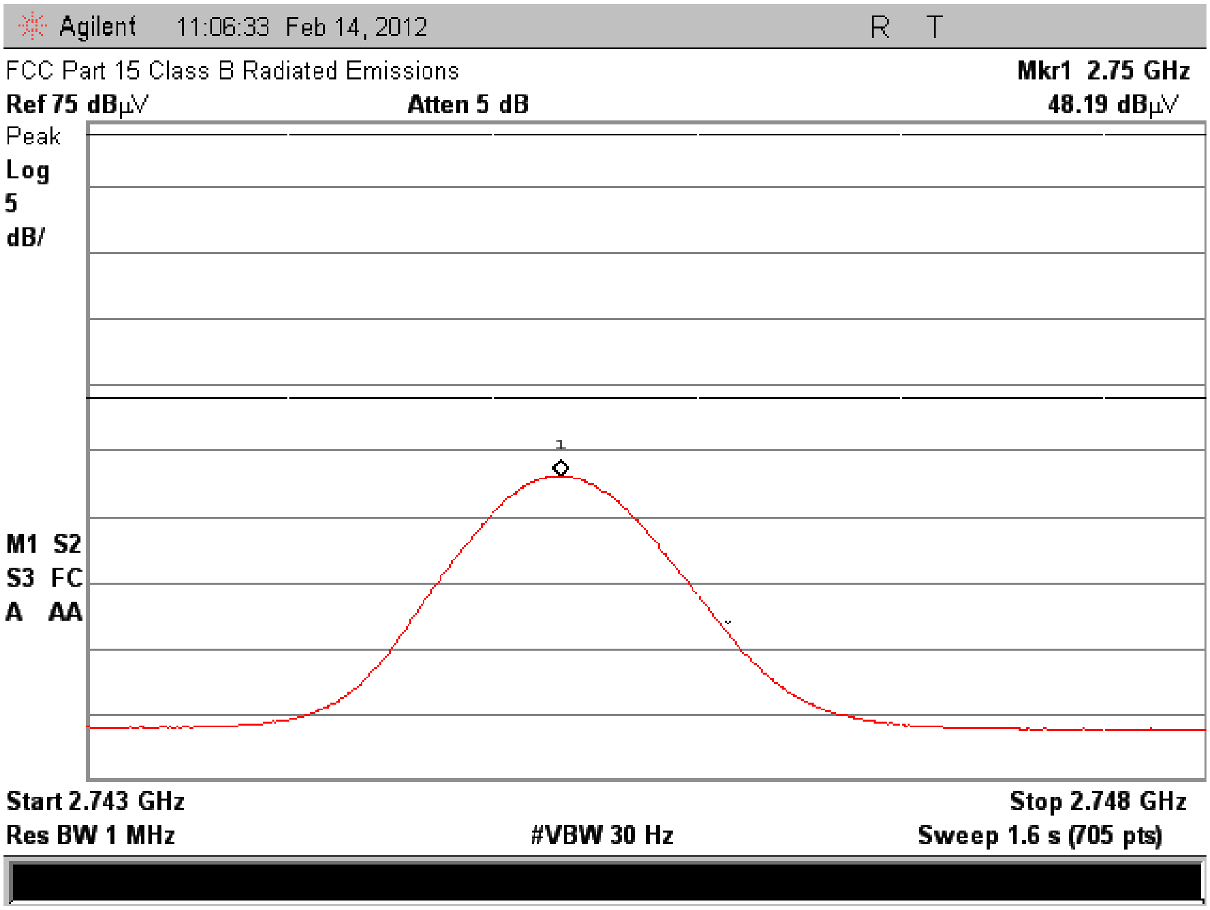


Figure 5.2-11 – Zoomed Average Field Strength Measurement of the Third Harmonic for Channel 24 Operation

Notes:

As mentioned, the frequency of the second highest emission was 2.747 GHz; the third harmonic. This emission was greater than 20 dB down from the fundamental but it did fall in the 2690 MHz – 2900 MHz restricted band. The field strength level measured with the average detector relative to the average limit was 48.2 dBµV/m; 5.8 dB below the limit. For this measurement, the 1000 MHz HPF was placed at the input of the pre-amplifier. Its loss at the measurement frequency was measured and corrected for in the results above. Under these conditions, the peak detector level was 50.8 dBµV/m.

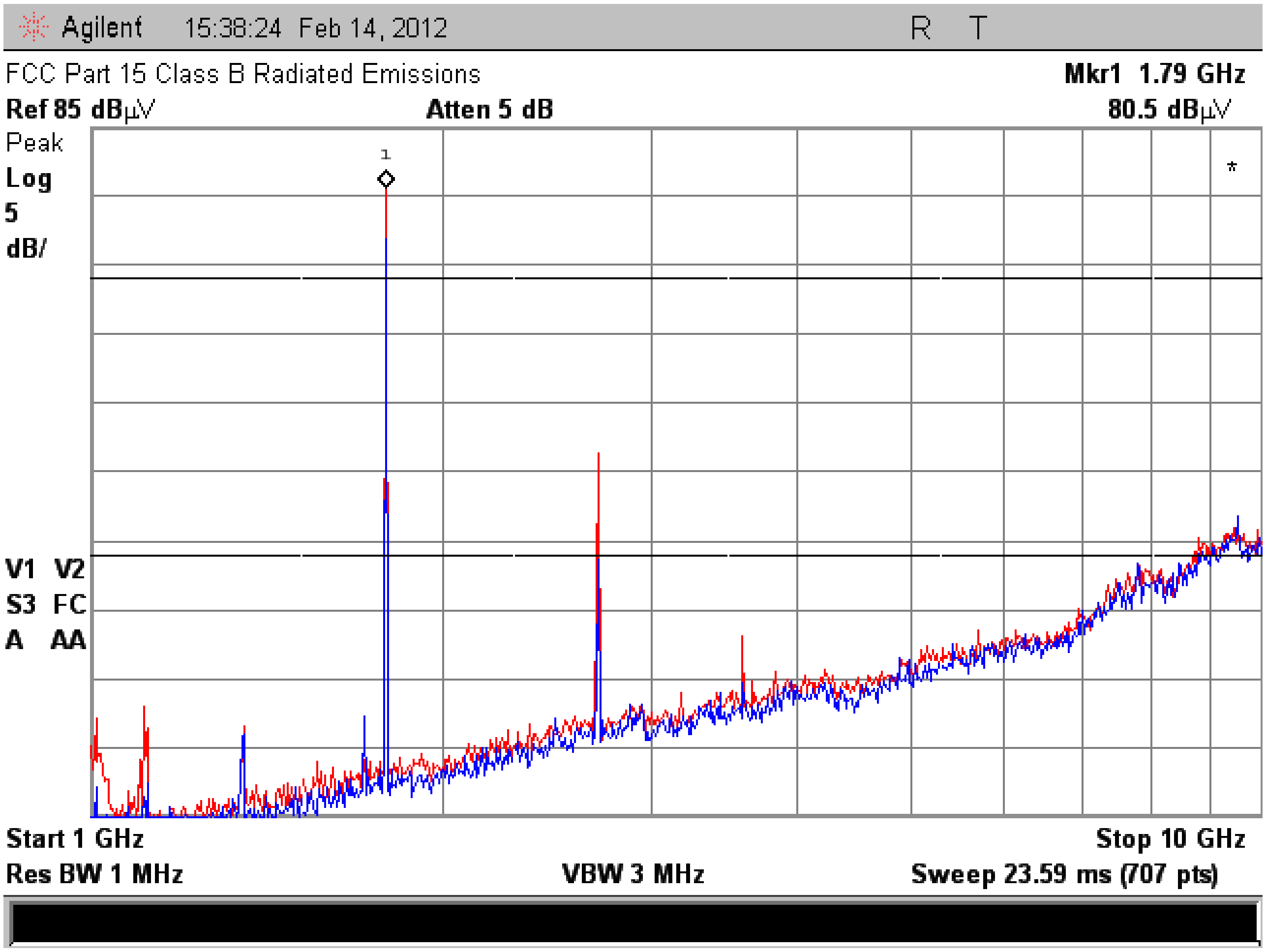


Figure 5.2-12 – Radiated Emissions 1 – 10 GHz (Peak Detector) Channel 0

Notes:

The red trace was with vertical polarity. The blue trace was with horizontal polarity. The DUT was set to transmit its continuous transmission test mode.

The frequency of the highest emission was 1.806 GHz; the second harmonic. Because this emission was greater than 20 dB down from the fundamental and it did *not* fall in a restricted band, it was judged to be acceptable.

The frequency of the second highest emission was 2.709 GHz; the third harmonic. This emission was greater than 20 dB down from the fundamental but it did fall in the 2690 MHz – 2900 MHz restricted band. The field strength level was below the peak limit but would have to be measured with the average detector relative to the average limit.

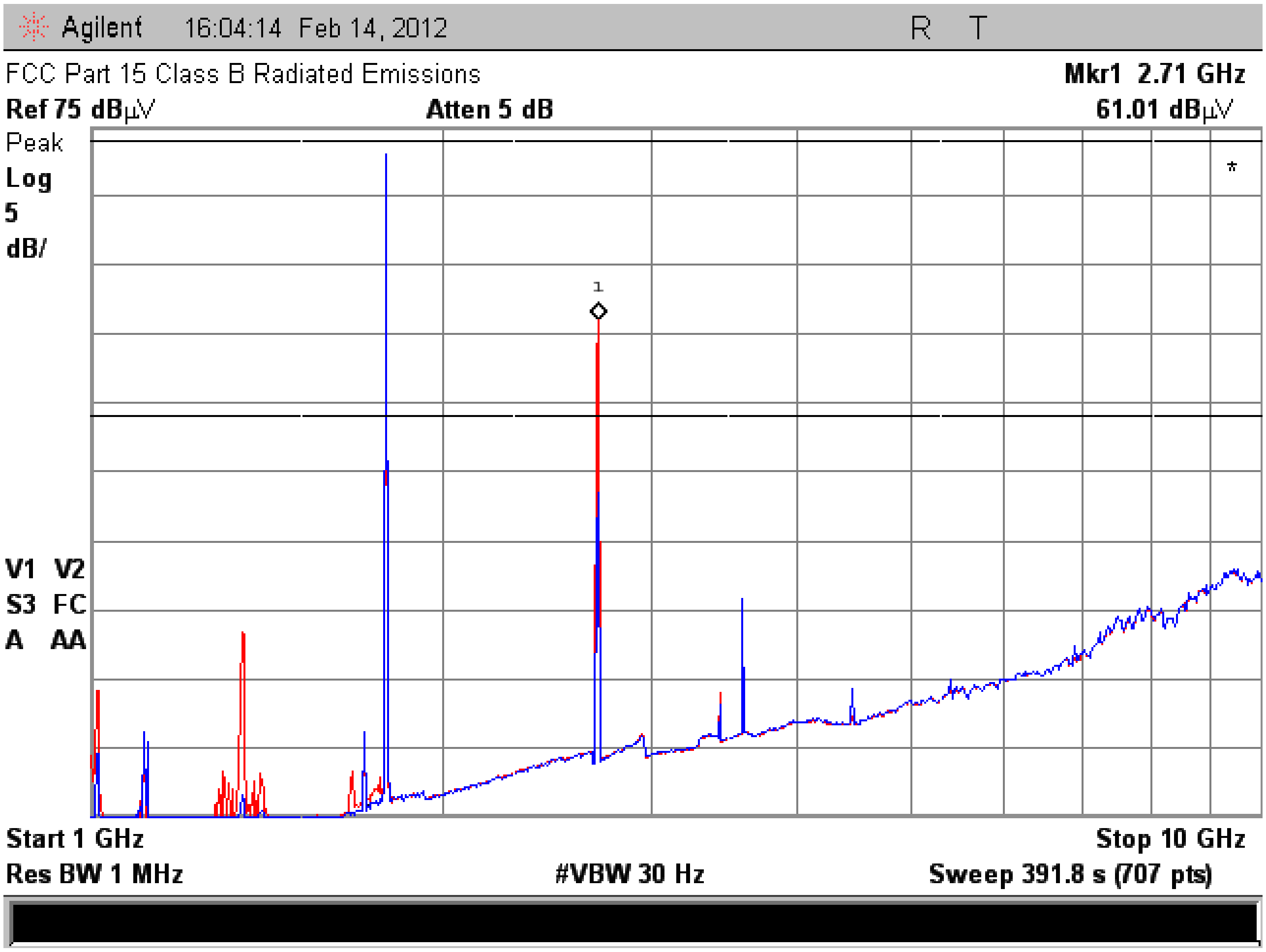


Figure 5.2-13 – Radiated Emissions 1 – 10 GHz (Average Detector) Channel 0

Notes:

The red trace was with vertical polarity. The blue trace was with horizontal polarity. The DUT was set to transmit its continuous transmission test mode.

The frequency of the highest emission was 1.806 GHz; the second harmonic. Because this emission was greater than 20 dB down from the fundamental and it did *not* fall in a restricted band, it was judged to be acceptable.

The frequency of the second highest emission was 2.709 GHz; the third harmonic. This emission was greater than 20 dB down from the fundamental but it did fall in the 2690 MHz – 2900 MHz restricted band. The field strength level when measured with the average detector was 61.0 dBµV/m. To determine if this emission was truly over the limit another measurement was made with a 1000 MHz high pass filter installed on the input of the preamplifier. This would allow for better sensitivity in the presence of the fundamental. Using this measurement technique this emission was below the average limit. The result of that test is shown in Figure 5.2-14.

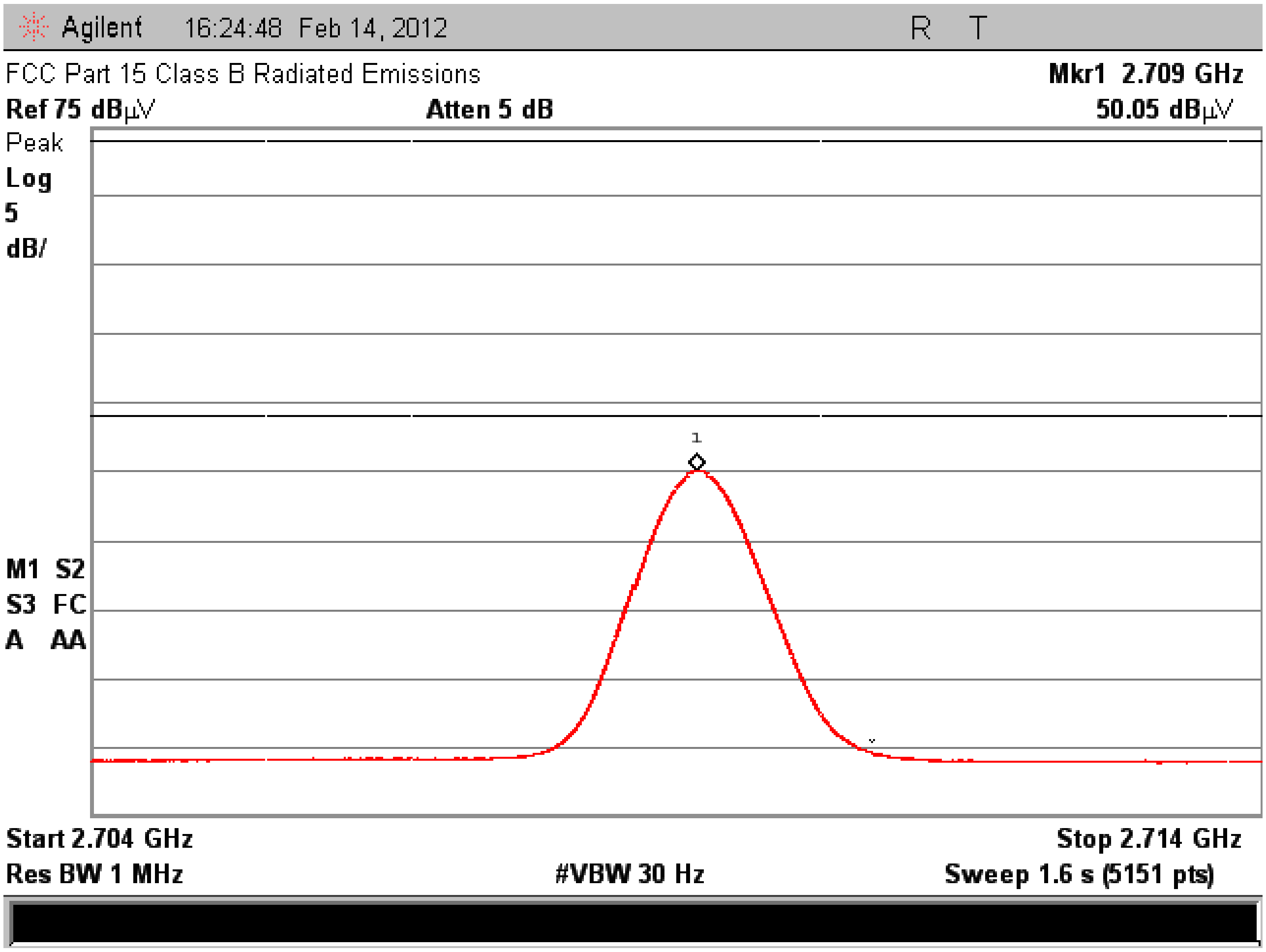


Figure 5.2-14 – Zoomed Average Field Strength Measurement of the Third Harmonic for Channel 0 Operation

Notes:

As mentioned, the frequency of the second highest emission was 2.709 GHz; the third harmonic. This emission was greater than 20 dB down from the fundamental but it did fall in the 2690 MHz – 2900 MHz restricted band. The field strength level measured with the average detector relative to the average limit was 50.1 dBμV/m; 3.9 dB below the limit. For this measurement, the 1000 MHz HPF was placed at the input of the pre-amplifier. Its loss at the measurement frequency was measured and corrected for in the results above. Under these conditions, the peak detector level was 51.8 dBμV/m.

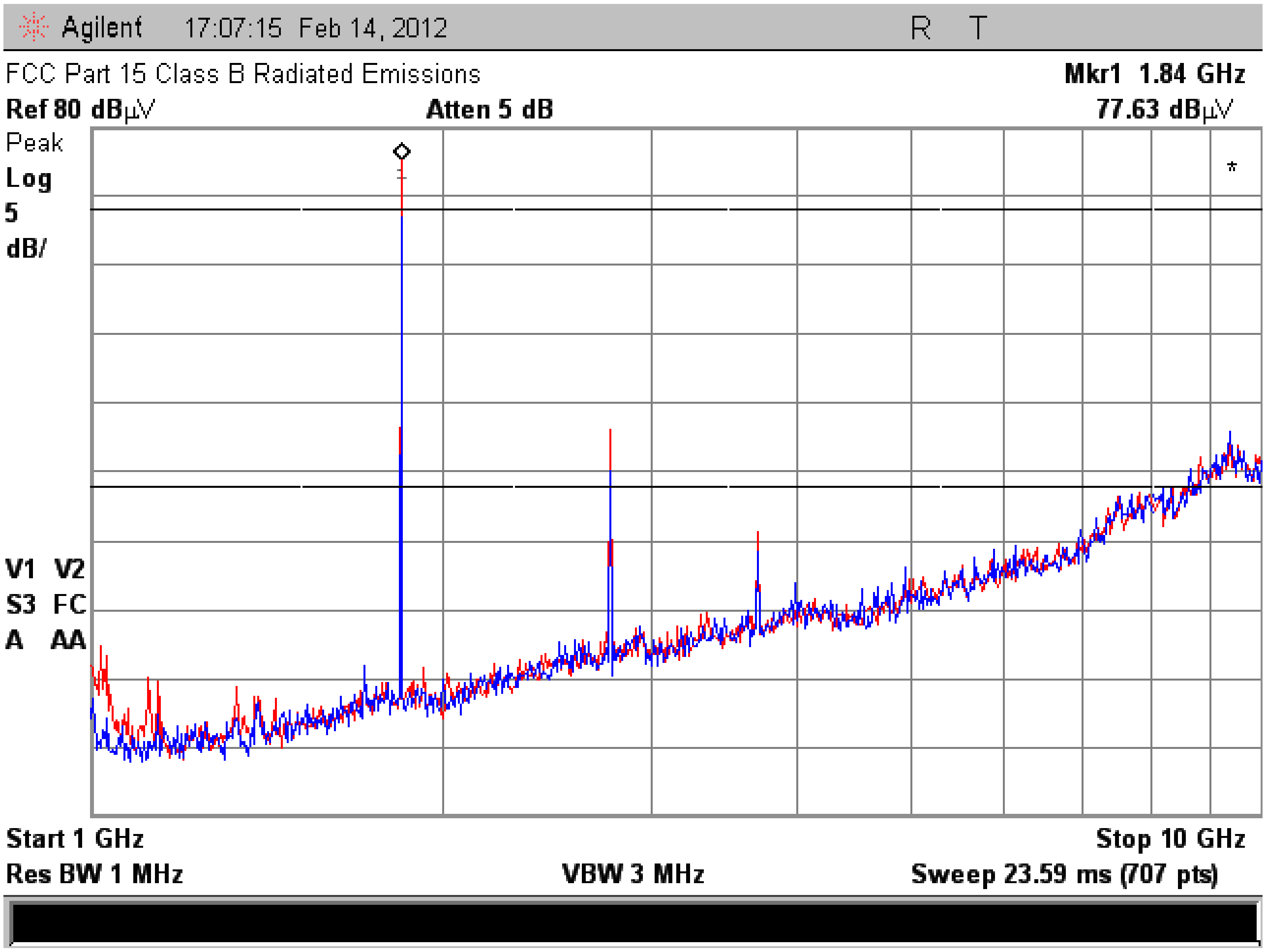


Figure 5.2-15 – Radiated Emissions 1 – 10 GHz (Peak Detector) Channel 49

Notes:

The red trace was with vertical polarity. The blue trace was with horizontal polarity. The DUT was set to transmit its continuous transmission test mode.

The frequency of the highest emission was 1.855 GHz; the second harmonic. Because this emission was greater than 20 dB down from the fundamental and it did *not* fall in a restricted band, it was judged to be acceptable.

The frequency of the second highest emission was 2.783 GHz; the third harmonic. This emission was greater than 20 dB down from the fundamental but it did fall in the 2690 MHz – 2900 MHz restricted band. The field strength level was below the peak limit but would have to be measured with the average detector relative to the average limit.

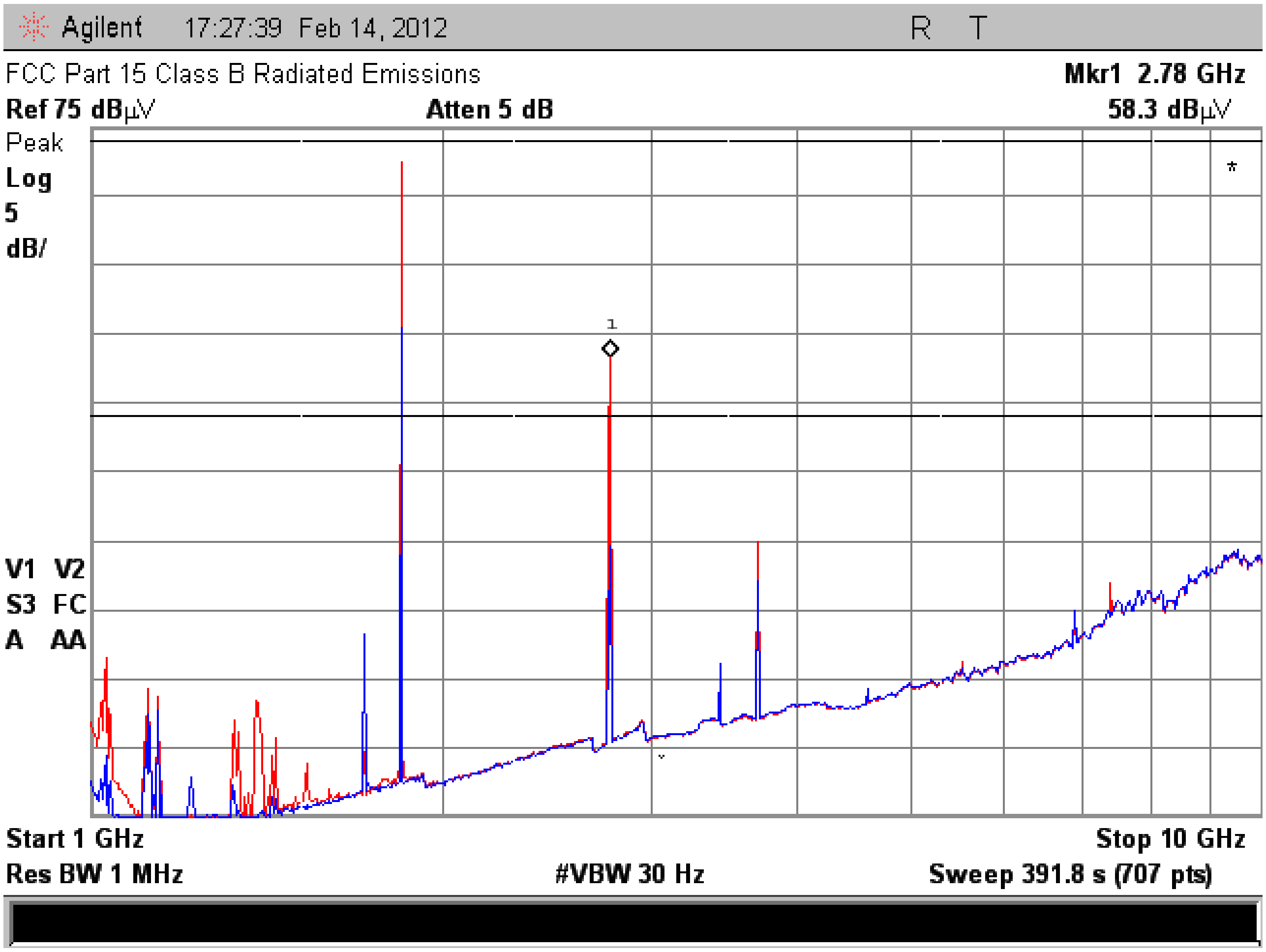


Figure 5.2-16 – Radiated Emissions 1 – 10 GHz (Average Detector) Channel 49

Notes:

The red trace was with vertical polarity. The blue trace was with horizontal polarity. The DUT was set to transmit its continuous transmission test mode.

The frequency of the highest emission was 1.855 GHz; the second harmonic. Because this emission was greater than 20 dB down from the fundamental and it did *not* fall in a restricted band, it was judged to be acceptable.

The frequency of the second highest emission was 2.783 GHz; the third harmonic. This emission was greater than 20 dB down from the fundamental but it did fall in the 2690 MHz – 2900 MHz restricted band. The field strength level when measured with the average detector was 58.3 dBµV/m. To determine if this emission was truly over the limit another measurement was made with a 1000 MHz high pass filter installed on the input of the preamplifier. This would allow for better sensitivity in the presence of the fundamental. Using this measurement technique this emission was below the average limit. The result of that test is shown in Figure 5.2-17.

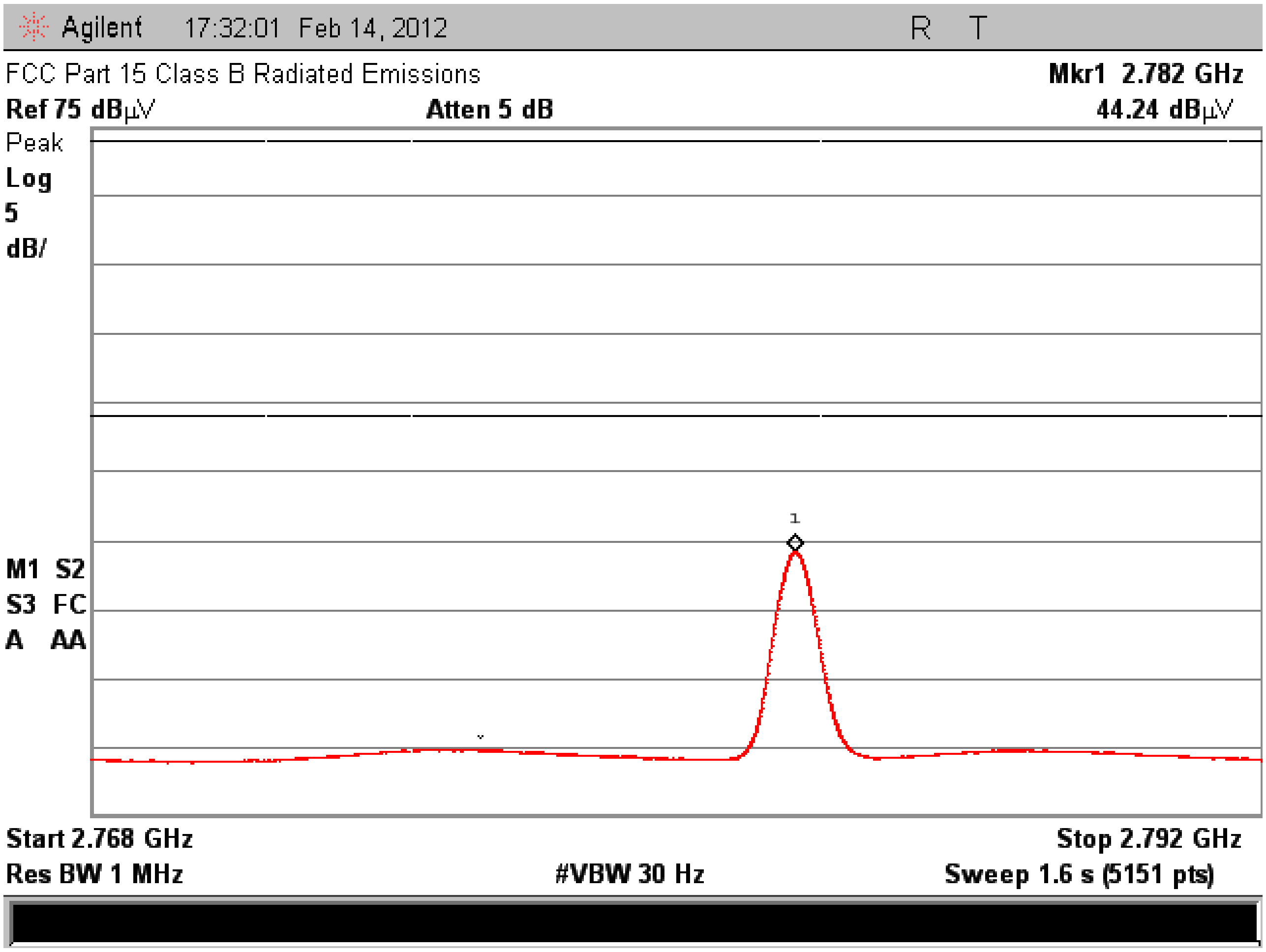


Figure 5.2-17 – Zoomed Average Field Strength Measurement of the Third Harmonic for Channel 49 Operation

Notes:

As mentioned, the frequency of the second highest emission was 2.783 GHz; the third harmonic. This emission was greater than 20 dB down from the fundamental but it did fall in the 2690 MHz – 2900 MHz restricted band. The field strength level measured with the average detector relative to the average limit was 44.2 dBµV/m; 9.8 dB below the limit. For this measurement, the 1000 MHz HPF was placed at the input of the pre-amplifier. Its loss at the measurement frequency was measured and corrected for in the results above. Under these conditions, the peak detector level was 48.2 dBµV/m.

Table 5.2-1 – Radiated Emissions QuasiPeak Levels 30 – 1000 MHz Transmitter On

Frequency (MHz)	QuasiPeak (dBµV/m)	Antenna height (cm)	Polarity	Turntable position (deg)	CF* (dB)	Margin (dB)	Limit (dBµV/m)
38.940000	16.2	196.0	V	60.0	14.1	23.8	40.0
76.260000	20.7	249.0	V	0.0	7.3	19.3	40.0
95.100000	20.6	100.0	V	183.0	10.4	22.9	43.5
127.140000	18.8	249.0	V	45.0	12.9	24.7	43.5
686.460000	33.4	149.0	V	255.0	22.8	12.6	46.0
907.260000	45.3	97.0	V	195.0	25.0	38.8	84.1
908.040000	45.0	100.0	V	195.0	25.0	39.1	84.1
909.240000	37.0	100.0	V	195.0	24.9	47.1	84.1
915.040000	104.1	100.0	V	180.0	24.7	N/A	N/A
921.960000	40.2	100.0	V	300.0	24.3	43.9	84.1

Table 5.2-2 – Radiated Emissions QuasiPeak Levels 30 – 1000 MHz Transmitter Off

Frequency (MHz)	QuasiPeak (dBµV/m)	Antenna height (cm)	Polarity	Turntable position (deg)	CF* (dB)	Margin (dB)	Limit (dBµV/m)
30.120000	16.4	100.0	V	0.0	18.9	23.6	40.0
44.220000	9.7	100.0	V	70.0	11.1	30.3	40.0
76.280000	20.8	100.0	V	198.0	7.3	19.2	40.0
95.060000	23.7	100.0	V	0.0	10.5	19.8	43.5
139.860000	14.7	100.0	V	179.0	12.1	28.8	43.5
247.920000	23.6	100.0	V	41.0	14.0	28.8	46.0

***CF is the antenna correction factor plus cable loss.**

Table 5.2-3 – Radiated Emissions Peak Levels 1 – 10 GHz

Frequency (GHz)	Peak (dBµV/m)	Antenna height (cm)	Polarity	Limit (dBµV/m)	Margin (dB)	Channel
1.83	74.7	109	Vertical	83.6	8.9	24
2.74	50.8	124	Vertical	74	23.2	24
1.81	78.1	100	Horizontal	83.2	5.1	0
2.71	51.8	131	Vertical	74	22.2	0

Table 5.2-4 – Radiated Emissions Average Levels 1 – 10 GHz

Frequency (GHz)	Average (dBµV/m)	Antenna height (cm)	Polarity	Limit (dBµV/m)	Margin (dB)	Channel
1.83	73.5	109	Vertical	83.6	10.1	24
2.74	48.2	124	Vertical	54	5.8	24
1.81	77.9	100	Horizontal	83.2	5.3	0
2.71	50.1	131	Vertical	54	3.9	0

* CF is the antenna correction factor and cable loss

Minimum Margin: **3.9 dBµV/m**

Measurement Uncertainty: +4.8 dB, -5.2 dB

Test Personnel:

Date	Name	Signature
February 17, 2012	Peter J. Walsh, NCE	Peter J. Walsh

5.3 Test Instrumentation Used, Radiated Measurement

Type	Manufacturer/ Model No.	Serial Number	Calibration Due Date
EMI Receiver	Rohde & Schwarz ESCS 30	825788/002	11/3/2012
Spectrum Analyzer	Agilent E7405A	MY42000055	3/18/2013
Preamplifier	Com-Power PA-122	181925	3/22/2012
1000 MHz HPF	TTE HC11-1000M-50-1554A	L9157	11/3/2012
Antenna	Chase EMCCBL6112B	2579	1/20/2014
Antenna	EMCO Horn Model 3115	9002-3393	3/14/2013
Antenna	Com-Power AL-130	121033	4/17/2013

Calibration and Traceability: All measuring and test equipment are calibrated and are traceable to the National Institute for Standards and Technology (NIST) and Methods.

5.4 Field Strength Calculation

The field strength (FS) is calculated by adding the antenna correction factor (ACF) and cable loss (CL) and subtracting the amplifier gain (AG) if any to the measured reading. The formula and a sample calculation are:

FS = Reading (dBµV/m) + ACF (dB) + CL (dB) – AG (dB)

FS = 25 + 12.1 + 0.7 + 0 = 37.8 dBµV/m

The Rohde & Schwarz Model ESCS 30 receiver and Agilent E7405A spectrum analyzer have the capability of automatically performing the field strength calculations. The amplitude level displayed on the receiver or analyzer represents the total measured field strength. This level is directly compared to the appropriate FCC limit to determine the actual margin of the DUT.

5.5 Radiated Emissions Photographs

Photo 5.5-1 - Front View of the Radiated Emissions Test Set-up

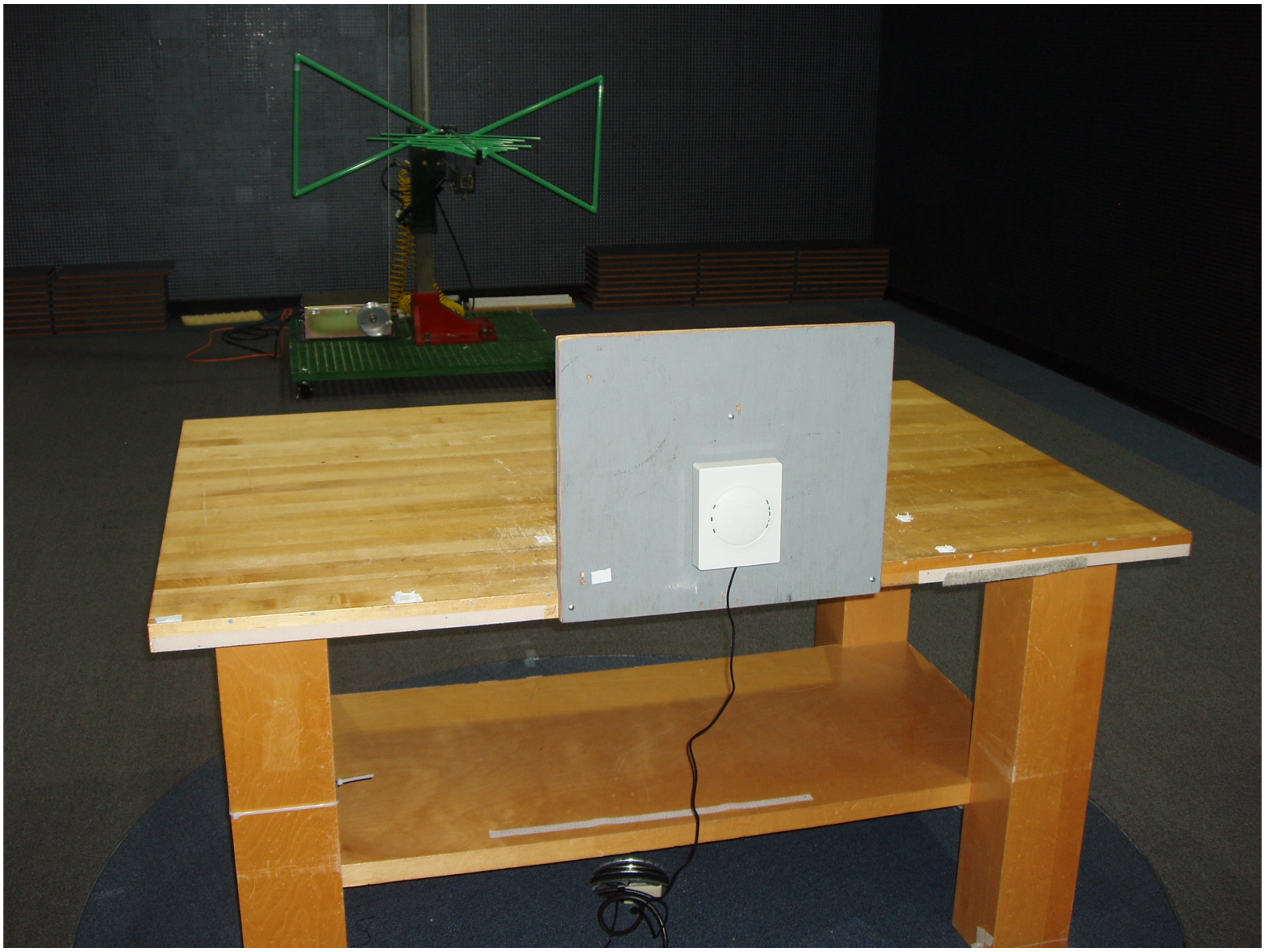


Photo 5.5-2 - Rear View of the Radiated Emissions Test Set-up with the Bi-log Antenna

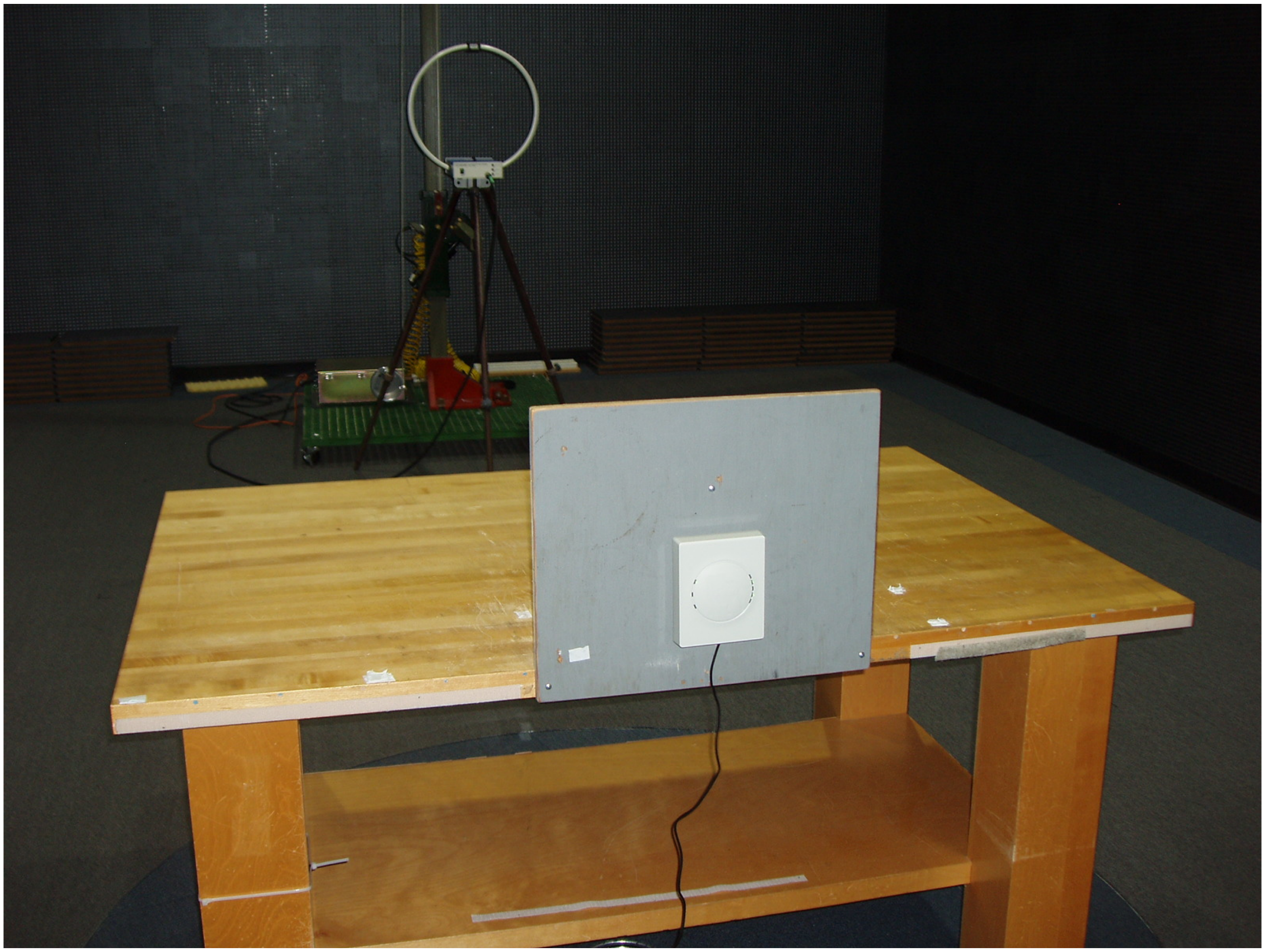


Photo 5.5-3 - Rear View of the Radiated Emissions Test Set-up with the Loop Antenna

6 ANTENNA REQUIREMENT

References: 47 C.F.R. § 15.203
RSS-GEN § 7.1.2

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

6.1 Test Procedure

Inspect the DUT.

6.2 Test Data

Compliance Verdict: PASS

This requirement is met because an internal PCB trace antenna is used.

6.3 Antenna Photographs

Photo 6.3-1 below shows the DUT’s internal antenna.

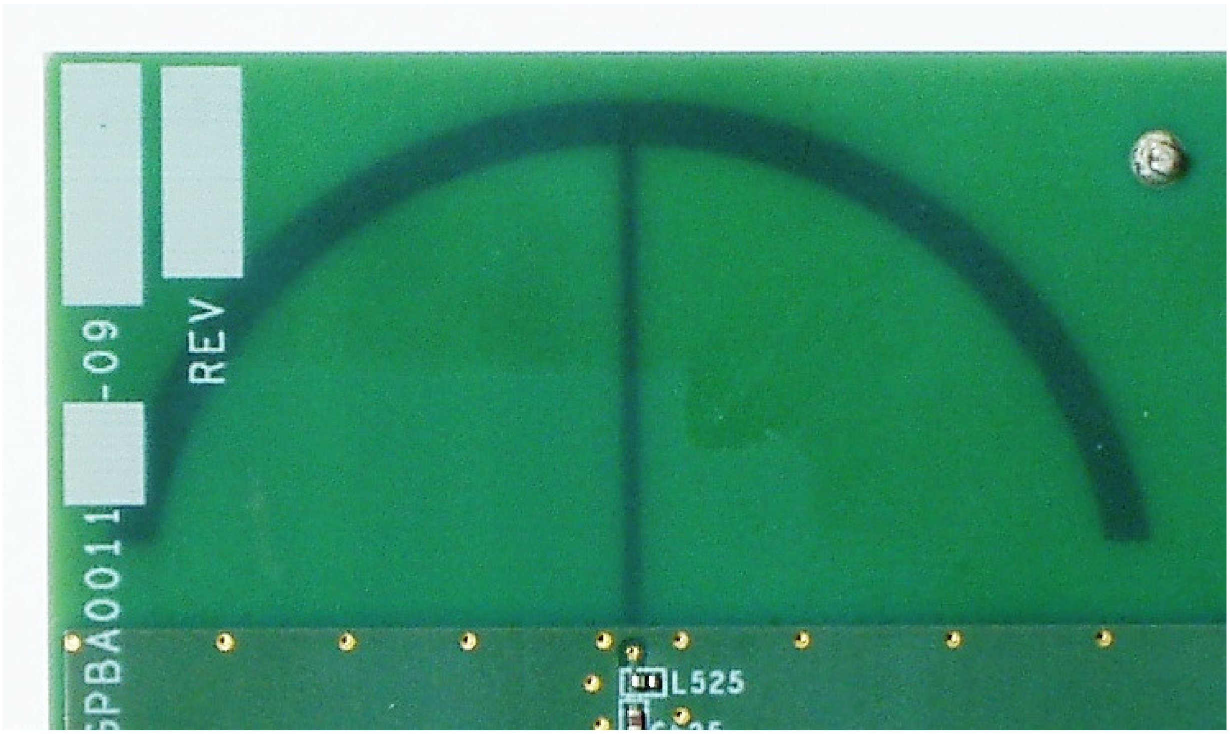


Photo 6.3-1 – Internal Antenna

7 BANDWIDTH DATA

References: 47 C.F.R. § 15.247 (a) (2)
RSS-210 § A8.1

(a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(i) For frequency hopping systems operating in the 902–928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

7.1 Test Procedure

The measurement is made using a direct connection between the DUT's antenna connection and the spectrum analyzer. The spectrum analyzer's resolution bandwidth (RBW) is set to 100 kHz and its span set to encompass the full bandwidth of the emission. The DUT is conditioned to transmit at its maximum duty cycle.

7.2 Test Data

Compliance Verdict: PASS

Figures 7.2-1 through 7.2-3 show the 20 dB bandwidth of the DUT operating on Channels 0, 24, and 49 respectively.

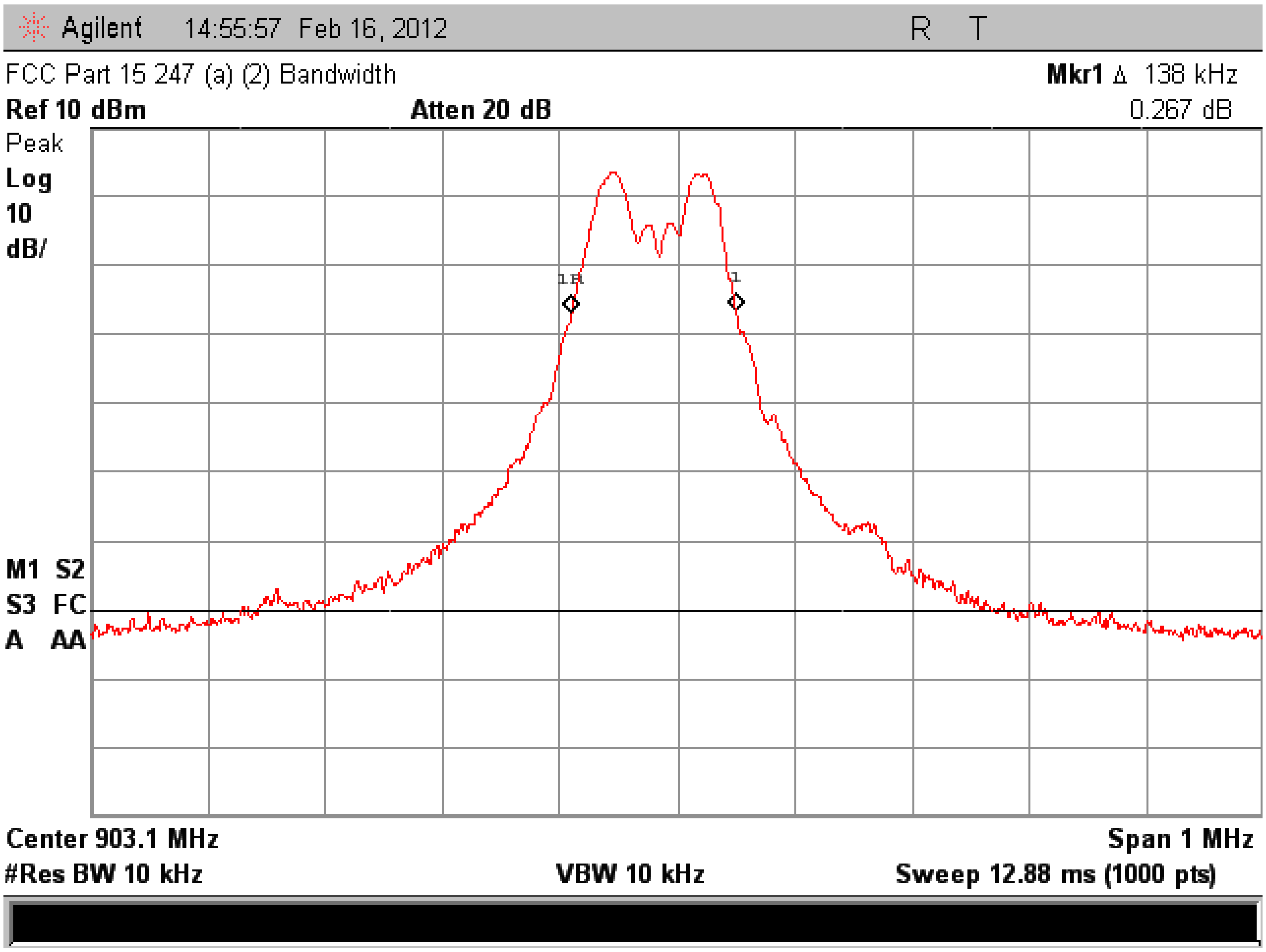


Figure 7.2-1 – Channel 0 Bandwidth

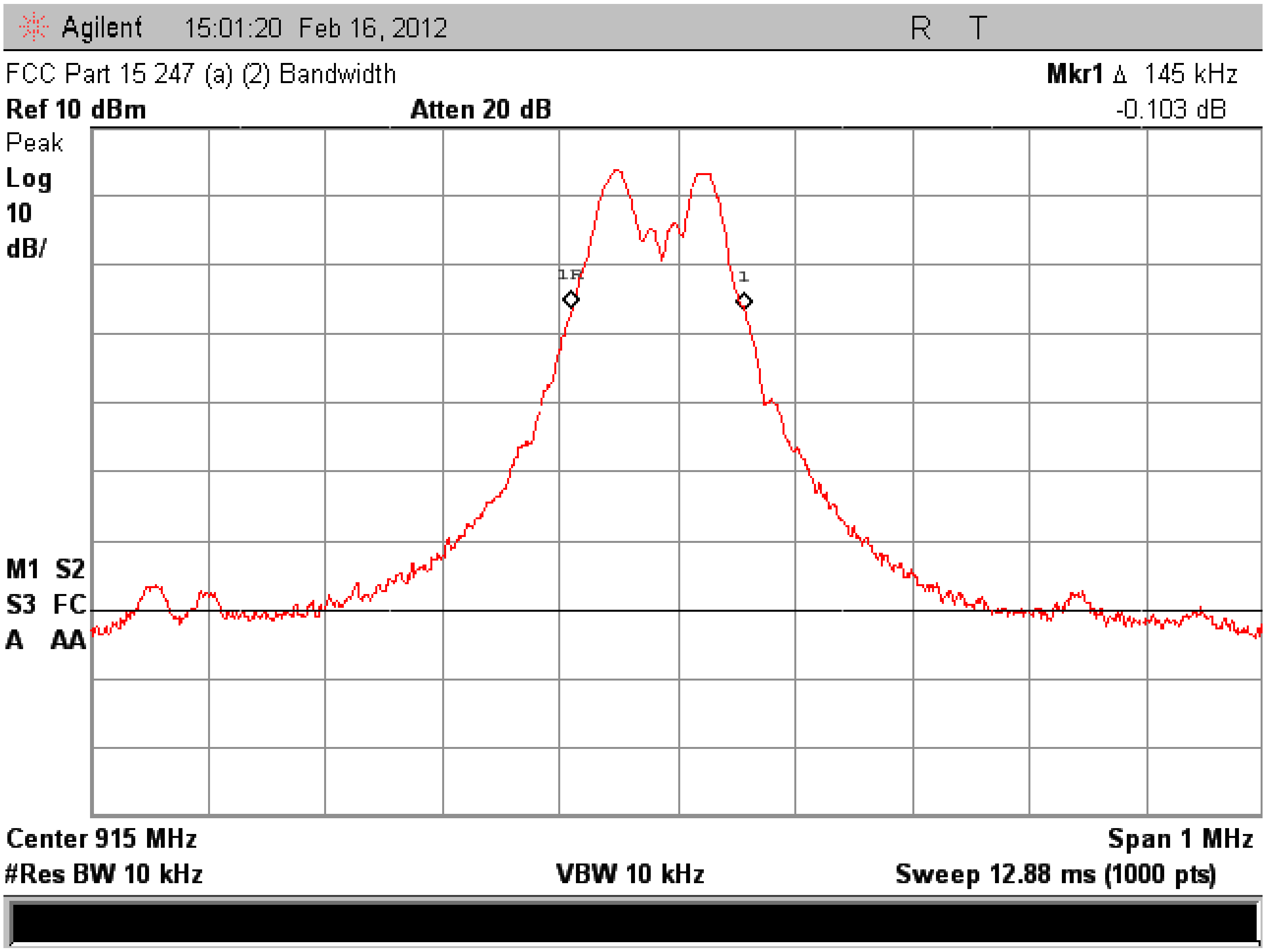


Figure 7.2-2 – Channel 24 Bandwidth

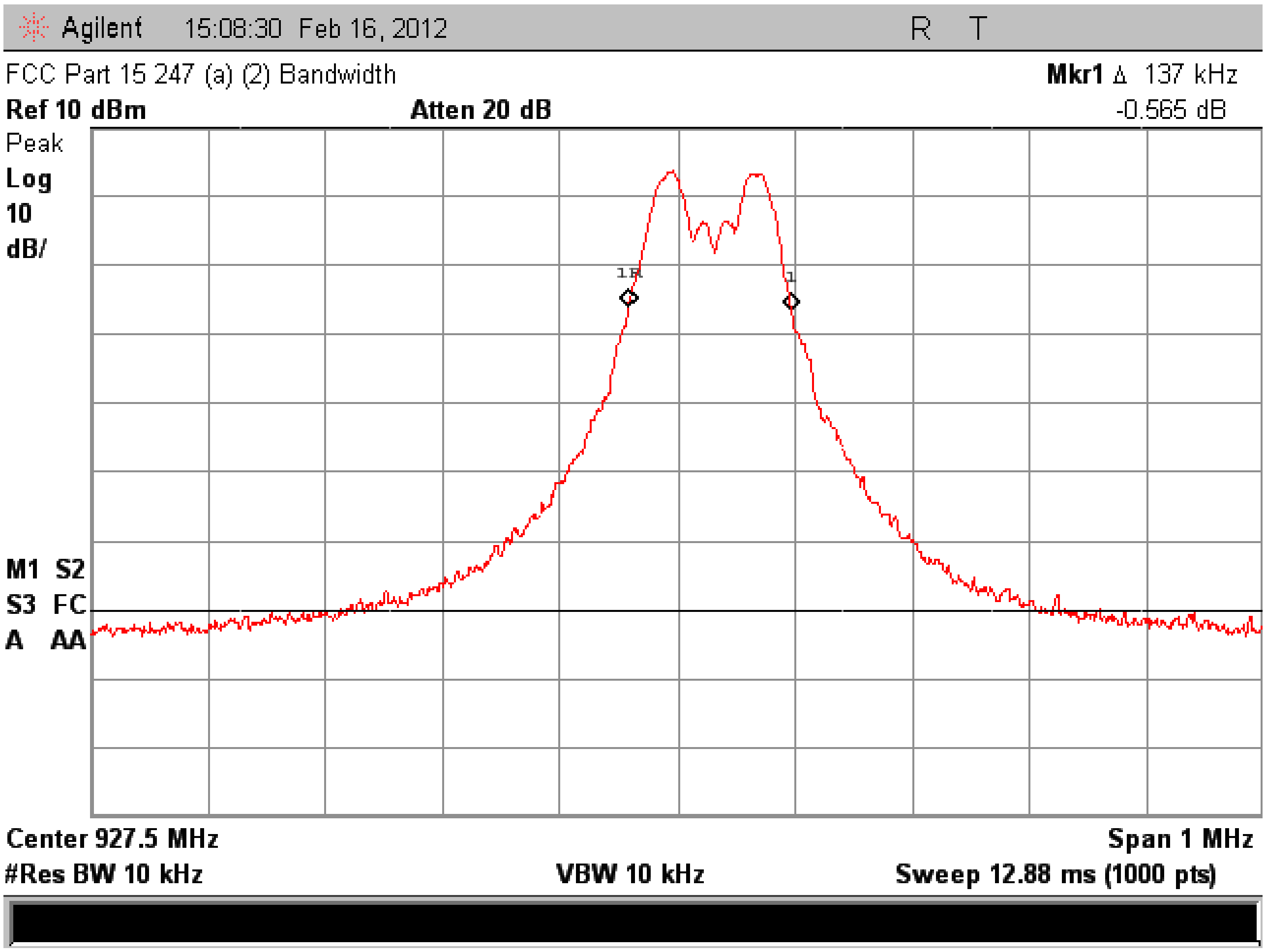


Figure 7.2-3 – Channel 49 Bandwidth

7.3 Test Instrumentation Used, Bandwidth Measurement

Type	Manufacturer/ Model No.	Serial Number	Calibration Due Date
Spectrum Analyzer	Agilent E7405A	MY42000055	3/18/2013

Calibration and Traceability: All measuring and test equipment are calibrated and are traceable to the National Institute for Standards and Technology (NIST) and Methods.

7.4 Photograph of the Setup for Conducted Measurements

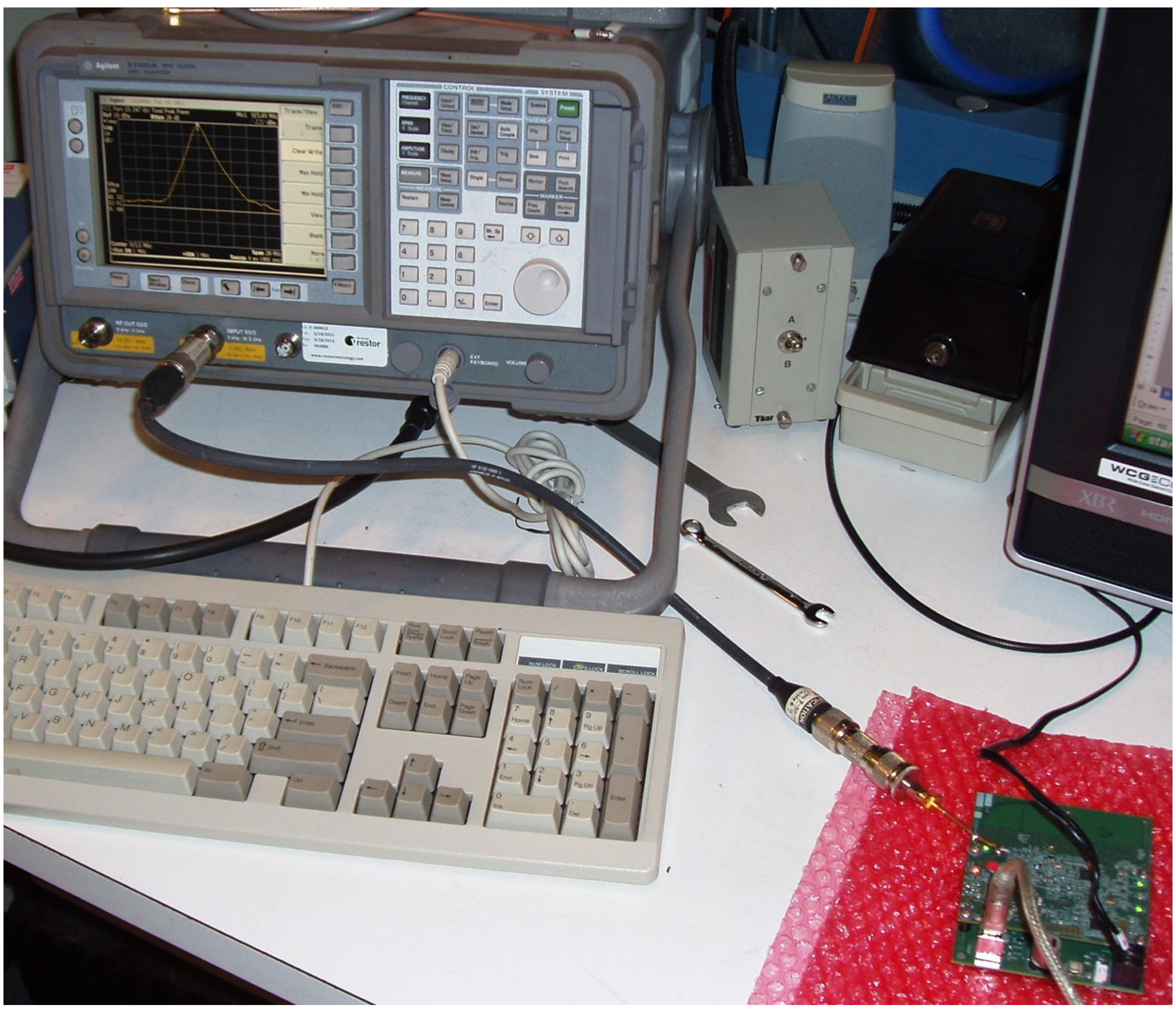


Photo 7.4-1 – Conducted Measurement Test -Setup

8 PEAK POWER DATA

References: 47 C.F.R. § 15.247 (b)
RSS-210 § A8.4 (1)

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(2) For frequency hopping systems operating in the 902–928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

(3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

References: 47 C.F.R. § 15.247 (c)
RSS-GEN § 7.1.2

(c) Operation with directional antenna gains greater than 6 dBi.

(1) Fixed point-to-point operation:

(i)Systems operating in the 2400-2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

(ii) Systems operating in the 5725-5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted output power.

(iii) Fixed, point-to-point operation, as used in paragraphs (c)(1)(i) and (c)(1)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum or digitally modulated intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

(2) In addition to the provisions in paragraphs (b)(1), (b)(3), (b)(4) and (c)(1)(i) of this section, transmitters operating in the 2400-2483.5 MHz band that emit multiple directional beams, simultaneously or

sequentially, for the purpose of directing signals to individual receivers or to groups of receivers provided the emissions comply with the following:

(i) Different information must be transmitted to each receiver.

(ii) If the transmitter employs an antenna system that emits multiple directional beams but does not emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device, i.e., the sum of the power supplied to all antennas, antenna elements, staves, etc. and summed across all carriers or frequency channels, shall not exceed the limit specified in paragraph (b)(1) or (b)(3) of this section, as applicable. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:

(A) The directional gain shall be calculated as the sum of 10 log(number of array elements or staves) plus the directional gain of the element or stave having the highest gain.

(B) A lower value for the directional gain than that calculated in paragraph (c)(2)(ii)(A) of this section will be accepted if sufficient evidence is presented, e.g., due to shading of the array or coherence loss in the beam forming.

(iii) If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the power limit specified in paragraph (c)(2)(ii) of this section. If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the limit specified in paragraph (c)(2)(ii) of this section. In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the limit specified in paragraph (c)(2)(ii) of this section by more than 8 dB.

(iv) Transmitters that emit a single directional beam shall operate under the provisions of paragraph (c)(1) of this section.

8.1 Test Procedure

The measurement is made using a direct connection between the DUT's antenna connection and the spectrum analyzer. The spectrum analyzer's resolution bandwidth (RBW) is set to 1 MHz, and its span set to encompass the full bandwidth of the emission, approximately 5 times the 20 dB bandwidth of the channel. The DUT is conditioned to transmit continuously by selecting the transmit continuous test mode. The trace is set to max hold. Since the radio's bandwidth is less than the 1 MHz resolution bandwidth, the total power is displayed directly.

8.2 Test Data

Compliance Verdict: PASS

First the total power limit must be determined. The system employed a single antenna with a gain declared by the manufacturer to be -2.0 dBi. Because the gain did not exceed 6.0 dBi by more than 3 dBi, it was not necessary to further reduce the DUT's output power. The 1 watt peak limit was applicable.

Table 8.2-1 below shows the measured power at the DUT's antenna terminal.

Table 8.2-1 – Measured Power on Channels 0, 24, and 49

Frequency (MHz)	Total Power (dBm)	Total Power (watts)	Channel	Power Setting
903.053	7.26	0.0053	0	0xf0
915.036	7.28	0.0053	24	0xf0
927.492	7.30	0.0054	49	0xf0

Figures 8.2-1 through 8.2-3 show the power measured by the spectrum analyzer as the 1 MHz resolution bandwidth was greater than the radio's bandwidth.

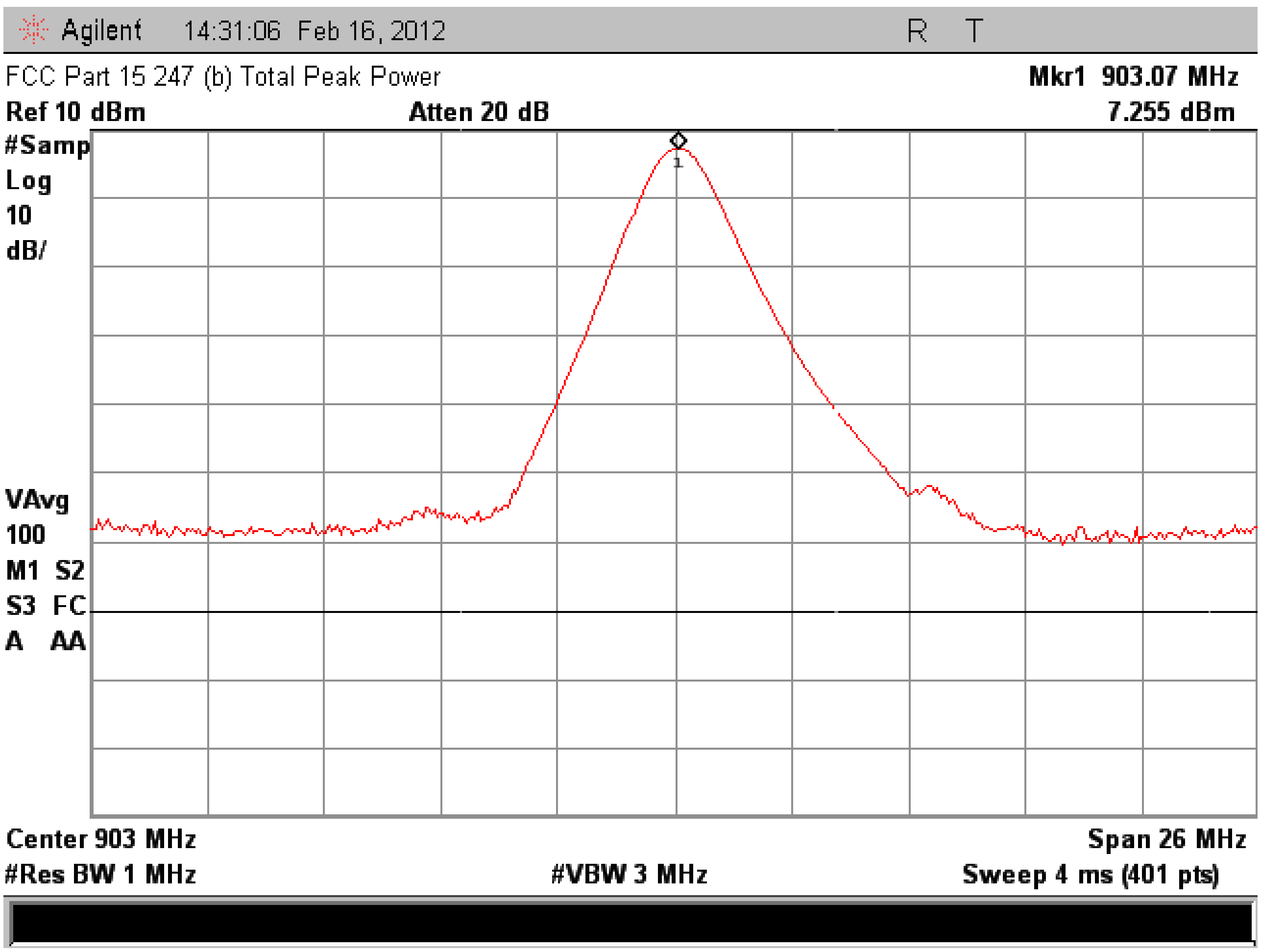


Figure 8.2-1 – Channel 0 Signal Power

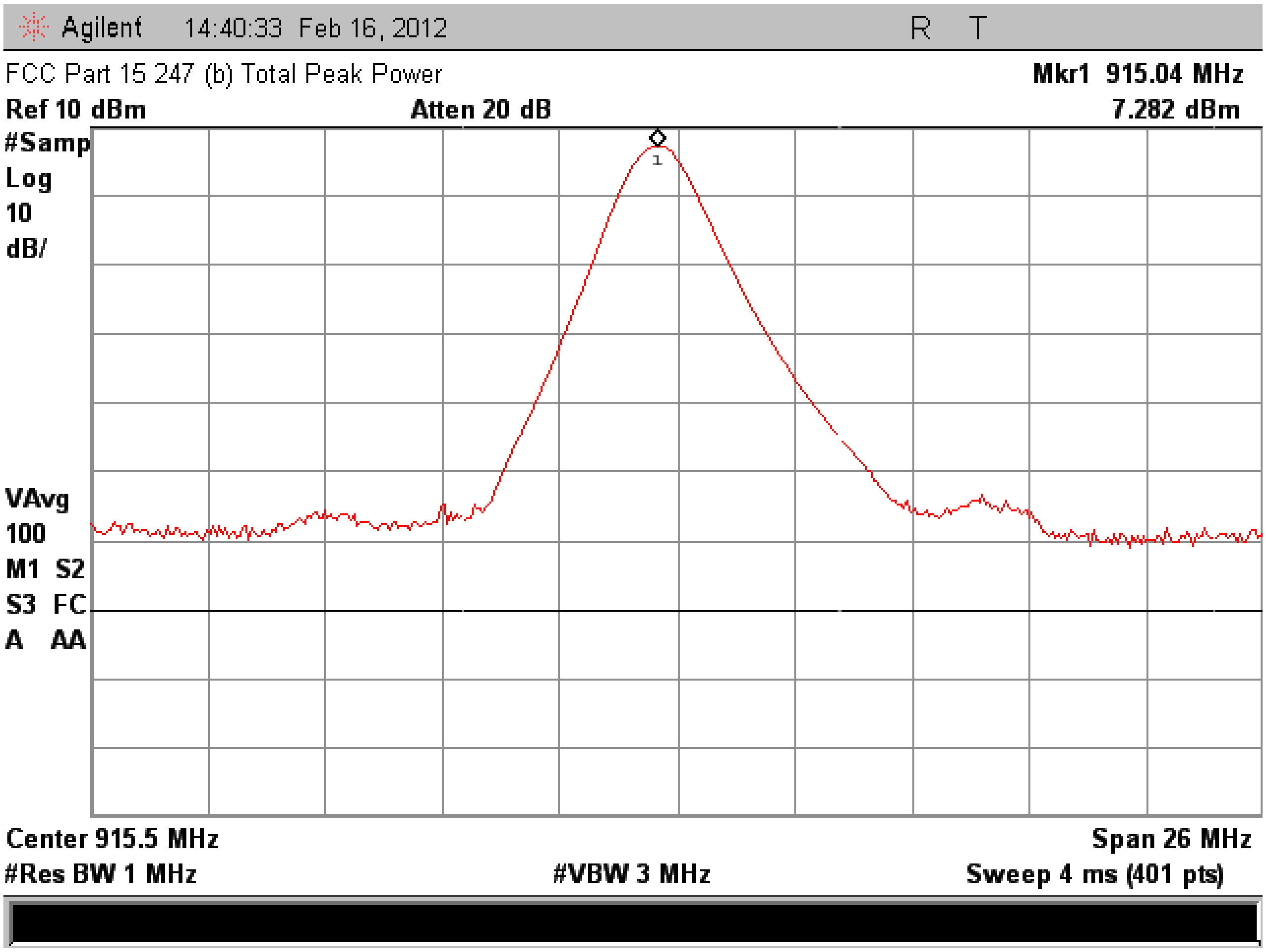


Figure 8.2-2 – Channel 24 Signal Power

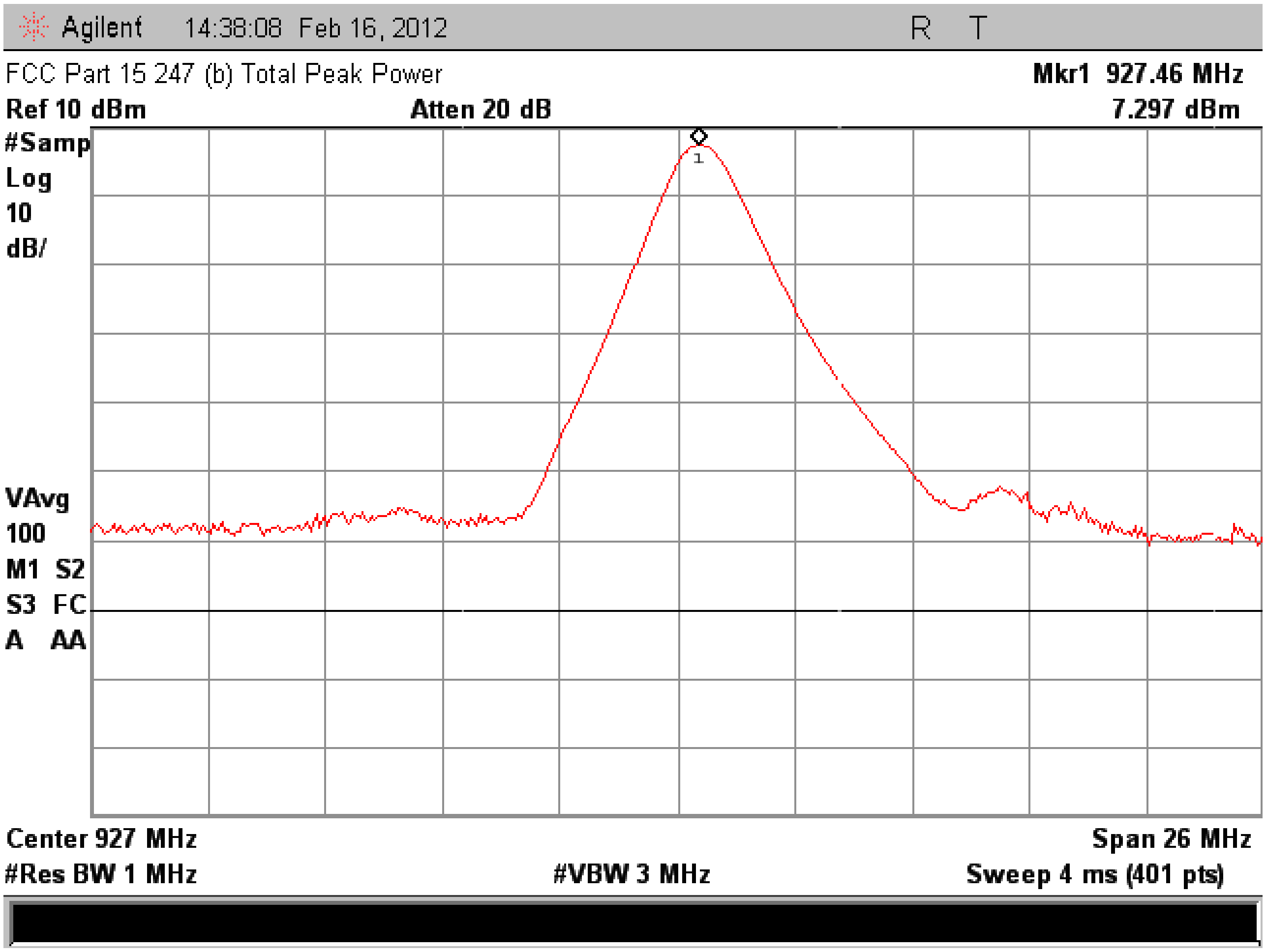


Figure 8.2-3 – Channel 49 Signal Power

8.3 Test Instrumentation Used, Peak Power Measurement

Type	Manufacturer/ Model No.	Serial Number	Calibration Due Date
Spectrum Analyzer	Agilent E7405A	MY42000055	3/18/2013

Calibration and Traceability: All measuring and test equipment are calibrated and are traceable to the National Institute for Standards and Technology (NIST) and Methods.

9 OUT OF BAND POWER DATA

References: 47 C.F.R. § 15.247 (d)
RSS-210 § A8.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

9.1 Test Procedure

The measurement is made using a direct connection between the DUT's antenna connection and the spectrum analyzer. The spectrum analyzer's resolution bandwidth (RBW) is set to 100 kHz and its span set to encompass the full bandwidth of the emission. The DUT is conditioned to transmit at its maximum duty cycle. The maximum peak power level of the emission is measured first. Next, a limit line is programmed at a level 20 dB below the measured maximum peak power level outside the operating band. Spurious emissions are measured relative to that limit.

Radiated emissions in the restricted bands are measured using the test method referenced in Section 5.1.

9.2 Test Data

Compliance Verdict: PASS

Figure 9.2-1 shows the out of band conducted data relative to the peak conducted level for the radio operating on channel 0. Figures 9.2-2 and 9.2-3 show the results for the radio operating on channels 24 and 49 respectively. These measurements were made with the DUT set in the transmit continuous test mode. The display line was set 20 dB lower than the peak level of the desired power. Figure 9.2-4 shows the results with the DUT operating in the frequency hopping test mode.[1] The harmonics and other spurious emissions were attenuated by at least 20 dB in all cases.

[1] This test was performed to ensure that the gating of transmitter did not give rise to unwanted, additional spurious emissions.

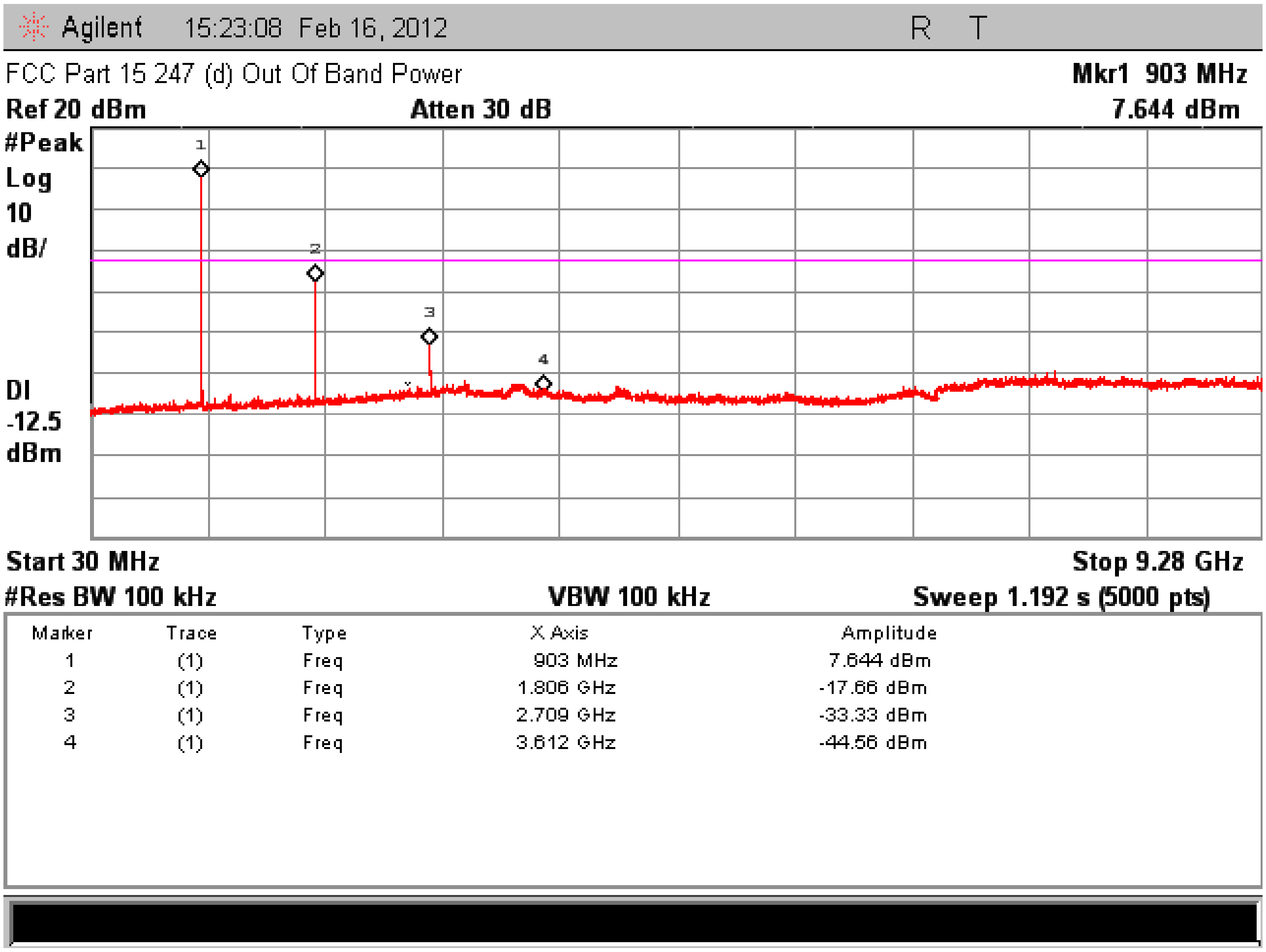


Figure 9.2-1 – Out of Band Conducted Data for Channel 0

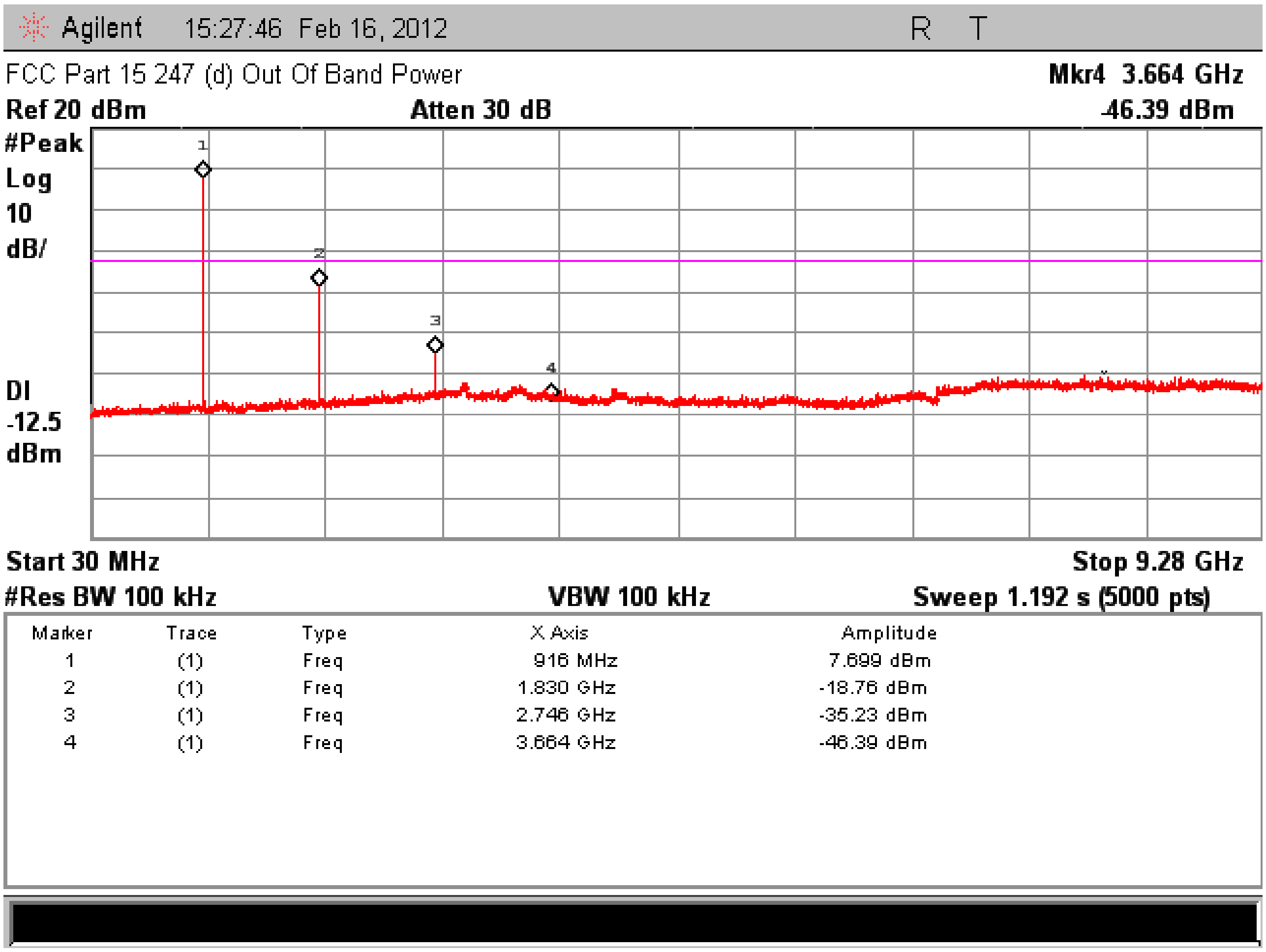


Figure 9.2-2 – Out of Band Conducted Data for Channel 24

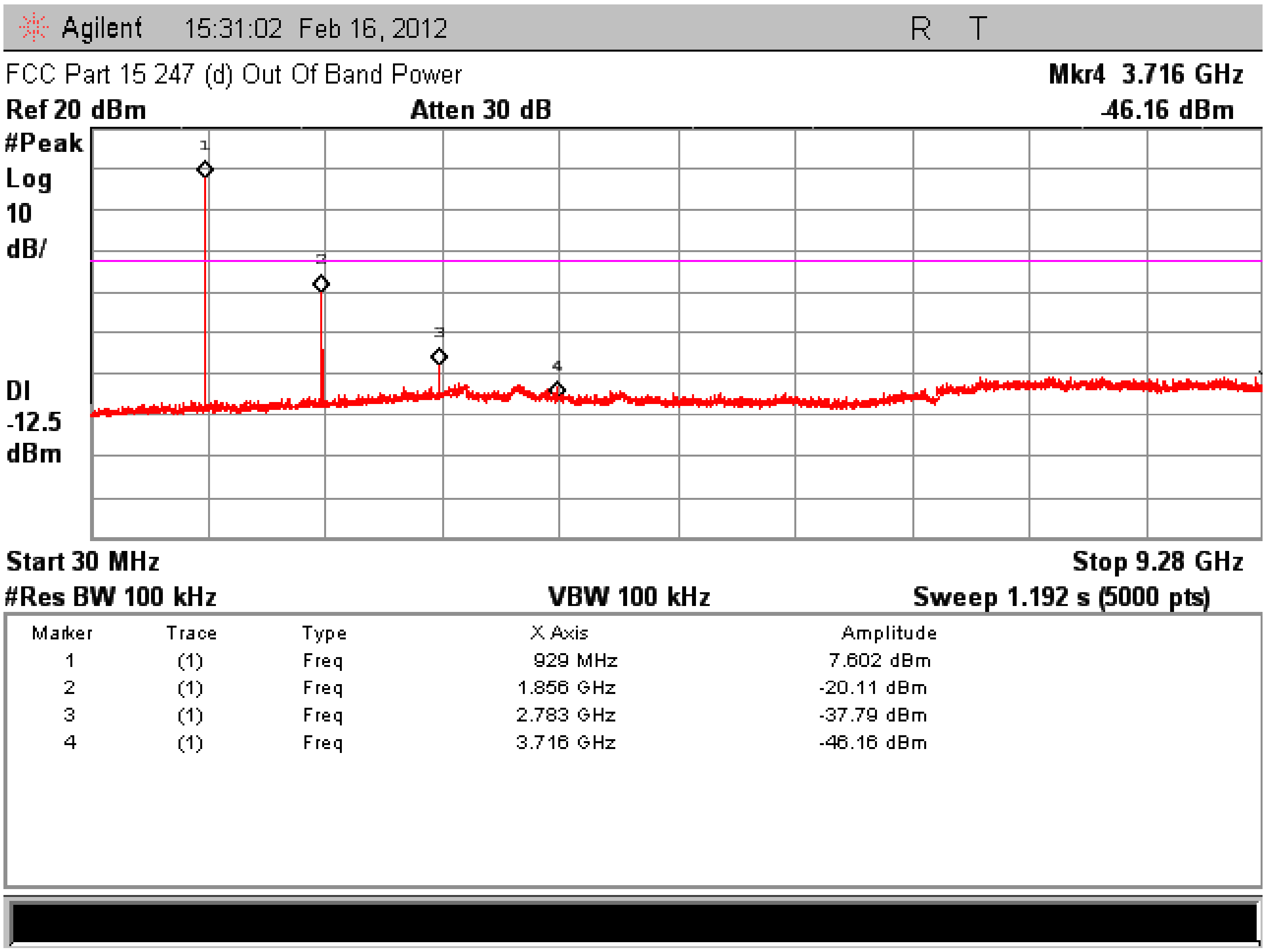


Figure 9.2-3 – Out of Band Conducted Data for Channel 49

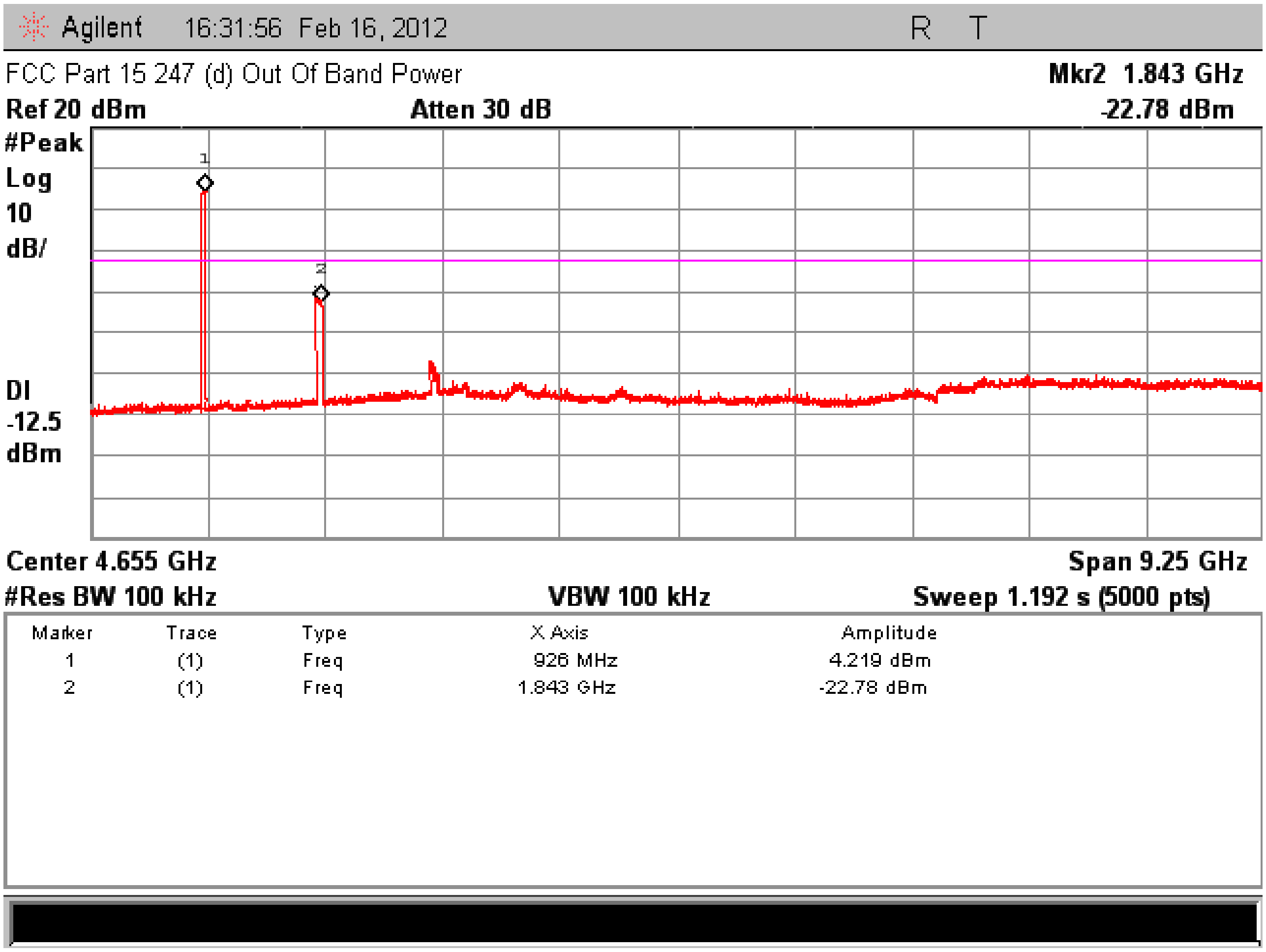


Figure 9.2-4 – Out of Band Conducted Data for Radio in the Frequency Hopping Mode

9.3 Test Instrumentation Used, Out of band Power Measurement

Type	Manufacturer/ Model No.	Serial Number	Calibration Due Date
Spectrum Analyzer	Agilent E7405A	MY42000055	3/18/2013

Calibration and Traceability: All measuring and test equipment are calibrated and are traceable to the National Institute for Standards and Technology (NIST) and Methods.

10 FREQUENCY HOPPING REQUIREMETNS

References: 47 C.F.R. § 15.247 (a)
RSS-210 § A8.1

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(i) For frequency hopping systems operating in the 902–928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

10.1 Test Procedure

Carrier Frequency Separation

The measurement is made using a direct connection between the DUT's antenna connection and the spectrum analyzer. The spectrum analyzer's resolution bandwidth (RBW) is set to 10 kHz and its span set to encompass the full bandwidth (1 MHz) of the emission. The DUT is conditioned to transmit at its maximum duty cycle. The center frequency is measured with the DUT transmitting on Channel 48 and then again with it transmitting on Channel 49. The difference between the two carrier frequencies was the separation.

Number of Hopping Channels

The method is similar to measuring the carrier frequency separation except that the span is set to occupy the full bandwidth of the 902 MHz to 928 MHz operating band. The DUT is conditioned to operate on all channels using the frequency hopping test mode and the number of channels is counted.

Time of Occupancy

The measurement is made using a direct connection between the DUT's antenna connection and the spectrum analyzer. The spectrum analyzer's resolution bandwidth (RBW) is set to 1 MHz and its span set to 0 Hz. The DUT is conditioned to transmit at its maximum duty cycle as represented by the frequency hopping test mode. The dwell time or maximum time the transmitter is on is then measured.

10.2 Test Data

Compliance Verdict: PASS

Based upon the measured 20 dB bandwidth of 145 kHz, the channel separation was measured relative to that constraint.

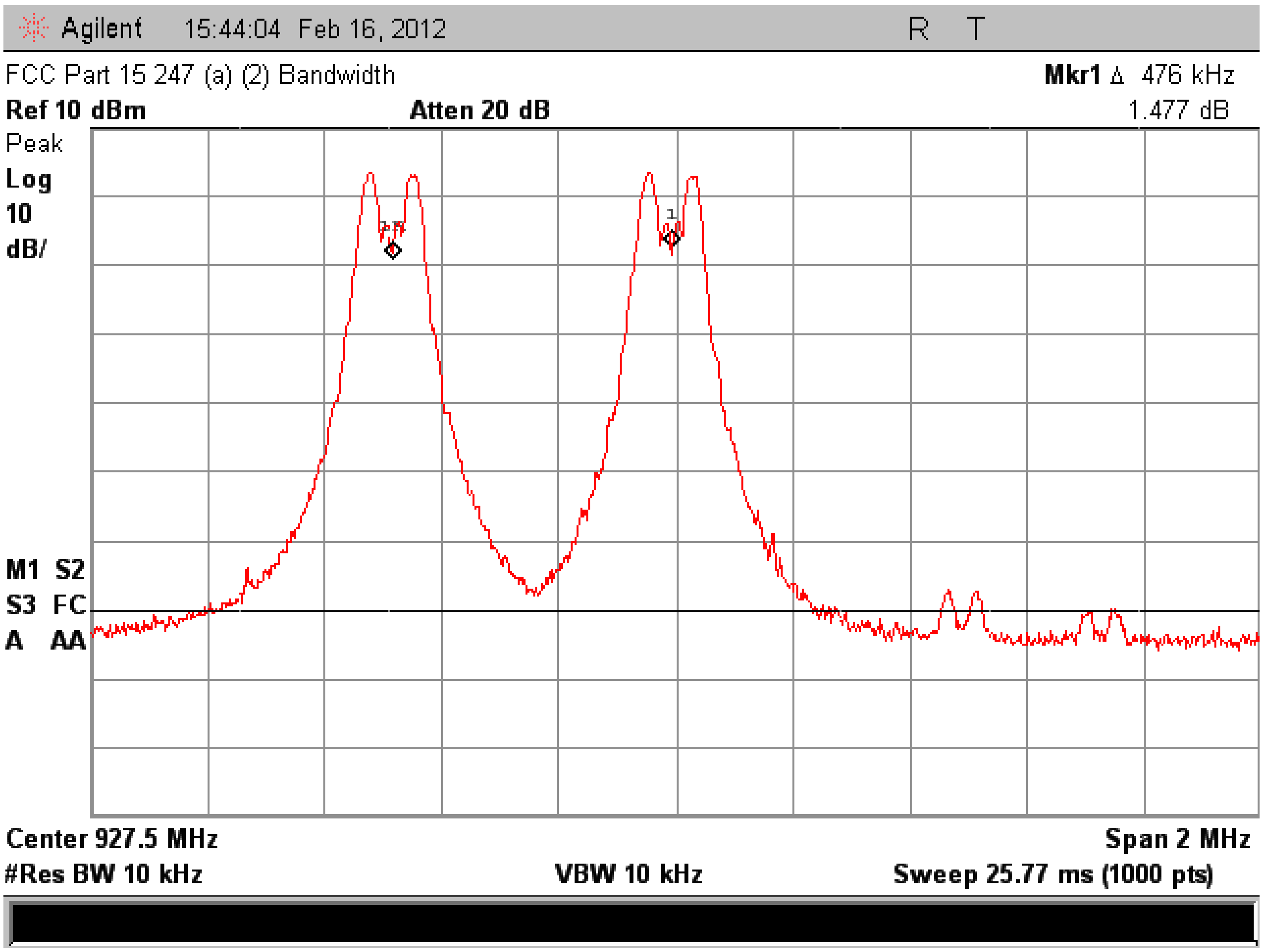


Figure 10.2-1 – Carrier Frequency Separation

The radio's specified minimum channel separation is 370 kHz. The measured separation between channels 48 and 49 was 476 kHz. Based upon this data, the DUT passes this requirement.

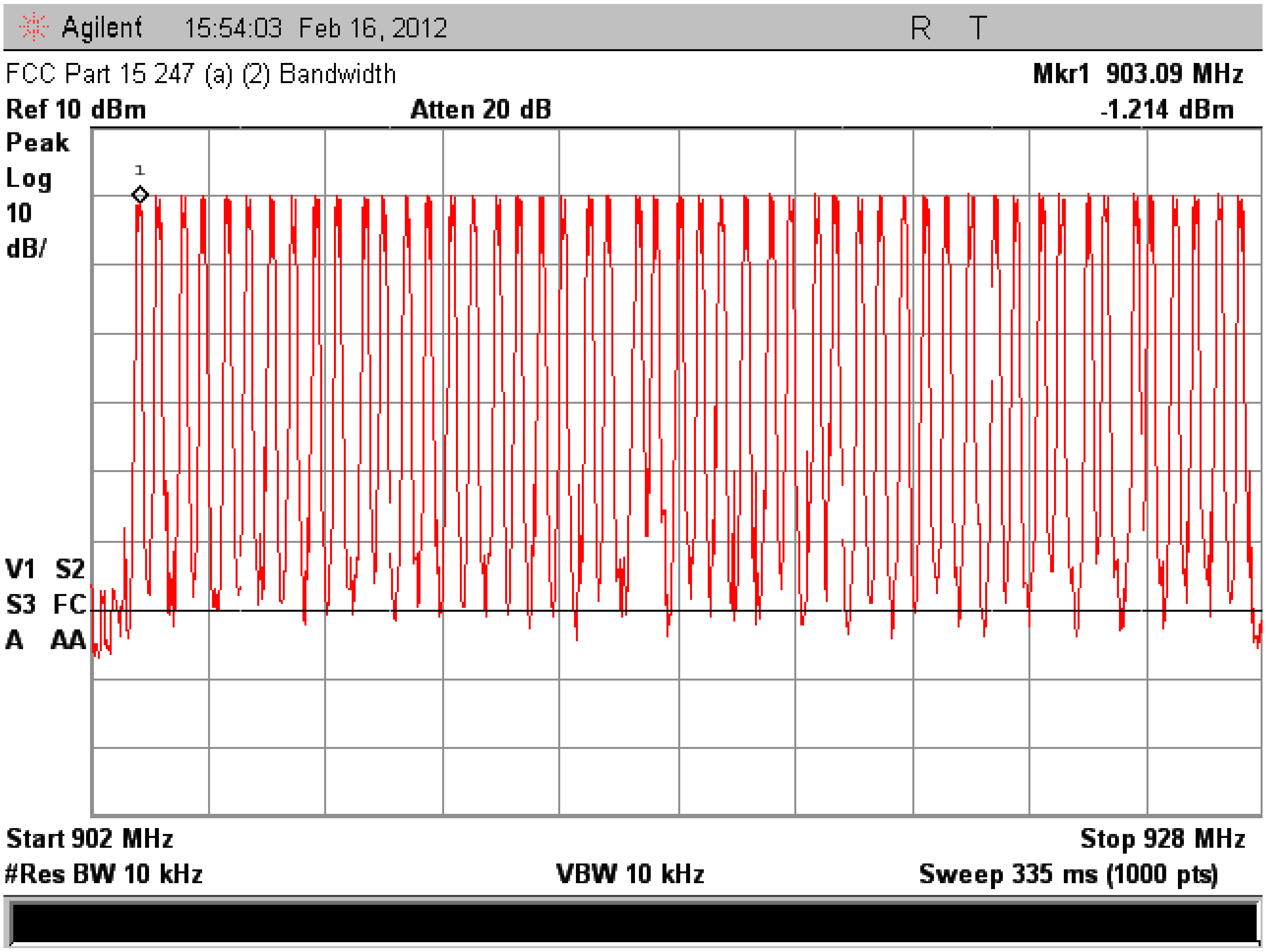


Figure 10.2-2 – Number of Hopping Channels

Notes:

The DUT operates on 50 channels as per FCC Part 15 requirements. The above plot was captured using the spectrum analyzer's max hold function as the radio cycled through its hopping sequence.

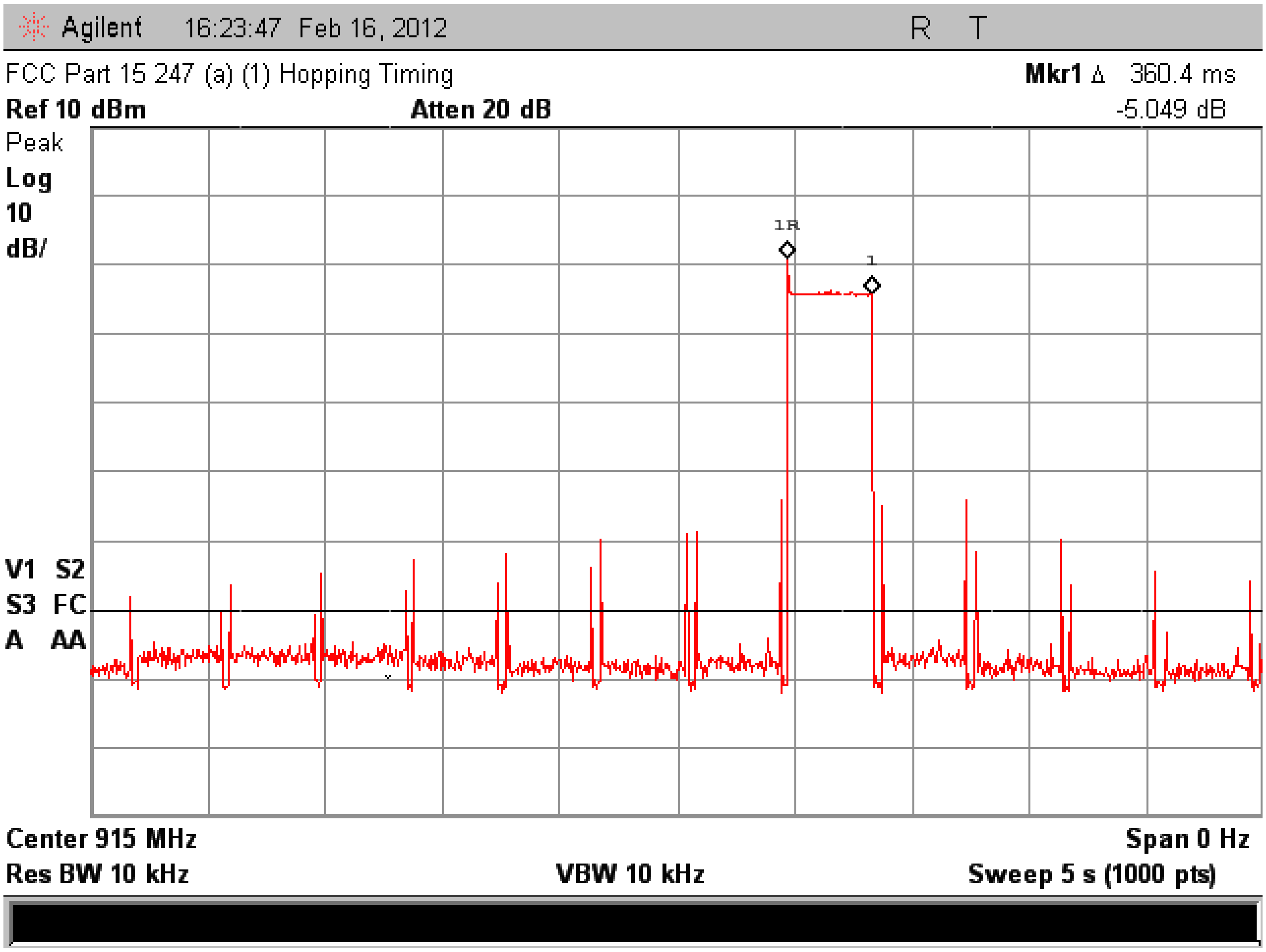


Figure 10.2-3 – Time of Channel Occupancy

Notes:

The DUT operates on a channel for 360 msec then hops to another channel. The above plot was taken monitoring the frequency used by channel 24.

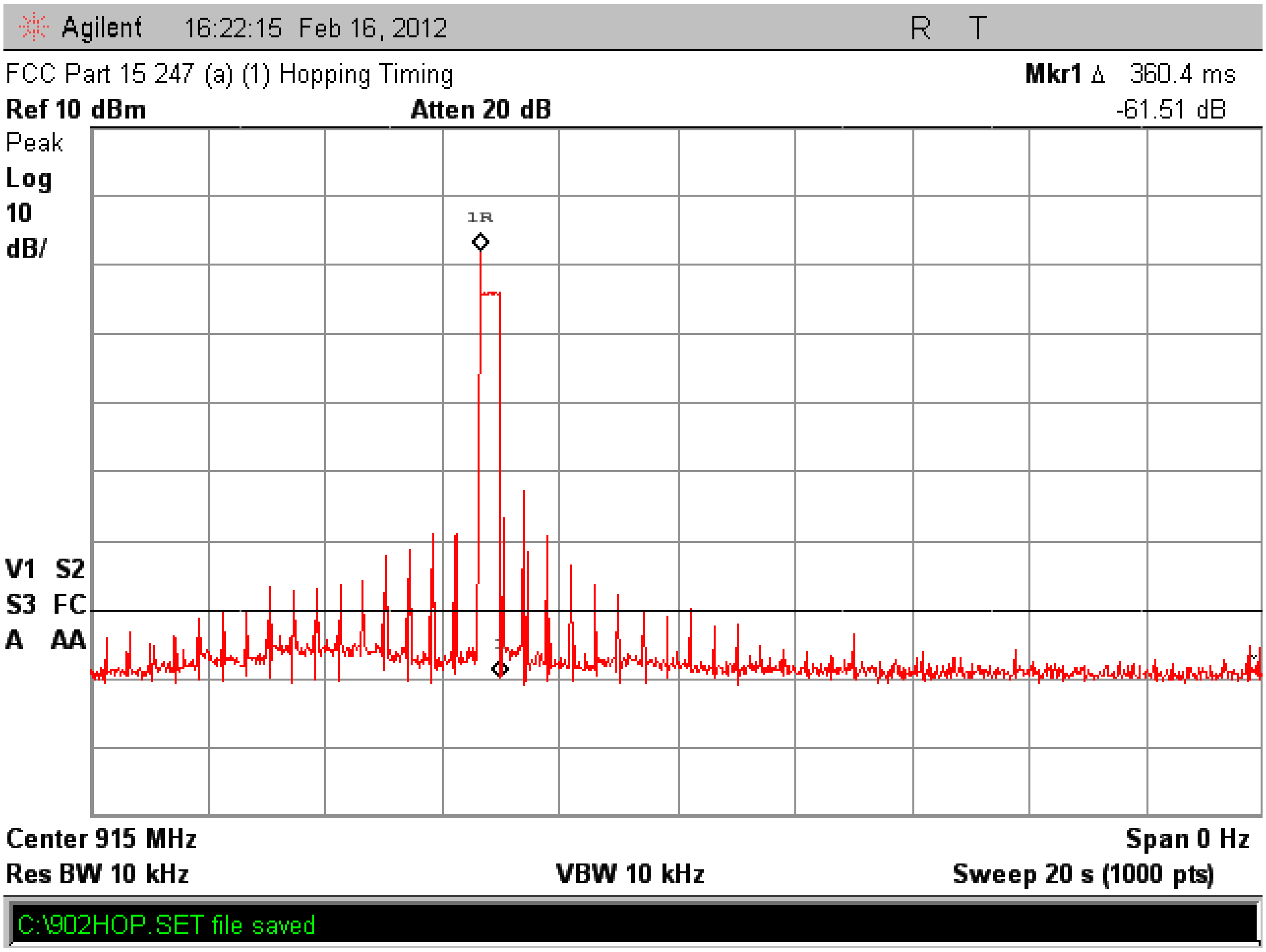


Figure 10.2-4 – Time of Channel Occupancy in a 20 Second Interval

Notes:

The DUT only transmits on a given channel once over a 20 second time internal.

10.3 Test Instrumentation Used, Frequency Hopping Measurements

Type	Manufacturer/ Model No.	Serial Number	Calibration Due Date
Spectrum Analyzer	Agilent E7405A	MY42000055	3/18/2013

Calibration and Traceability: All measuring and test equipment are calibrated and are traceable to the National Institute for Standards and Technology (NIST) and Methods.

11 DUTY CYCLE

References: 47 C.F.R. § 15.35 (c)
RSS-GEN § 4.5

Unless otherwise specified, e.g. §15.255(b), when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to notification or verification.

11.1 Test Procedure

The measurement is made as a field strength measurement except that the spectrum analyzer's frequency span is set to 0 Hz to facilitate a time domain measurement. The sweep time is set to 100 msec. The DUT is conditioned to transmit at its maximum duty cycle. The duty cycle is calculated by summing the on times and dividing by 100 msec.

11.2 Test Data

Compliance Verdict: None

The test mode used for radiated emissions measurements was the continuous transmission test mode. This was a 100 % duty cycle transmission. As such, a reduction in the field strength measurements based upon duty cycle was not necessary.

Refer to section 10 for time domain measurements with the DUT operating in the frequency hopping test mode.

11.3 Test Instrumentation Used, Duty Cycle Measurement

Type	Manufacturer/ Model No.	Serial Number	Calibration Due Date
Spectrum Analyzer	Agilent E7405A	MY42000055	3/18/2013

Calibration and Traceability: All measuring and test equipment are calibrated and are traceable to the National Institute for Standards and Technology (NIST) and Methods.

12 LABELING AND USER'S GUIDE REQUIREMENTS

12.1 FCC Label Statement

The FCC compliance label shall include the following information:

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

The FCC identifier or the unique identifier, as appropriate, must be displayed on the device.

The FCC ID number will be: YVAUG1000R

The Industry Canada ID number will be: IC: 10216A-UG1000R

Figure 12.1-1 below shows a drawing of the label.

Figure 12.1-1 - Sample Label

12.2 Instruction Manual Statements

The instruction manual must contain the following statements:

- Changes or modifications not expressly approved by the responsible party could void the user's authority to operate the equipment.

- This device may only be used with the approved internal antenna that is shipped with the unit and installed per installation instructions. The use of any other antennas will invalidate the unit's FCC Part 15 certification.

- This device has been designed to operate with the on-board PCB antenna. The use of an external antenna will require authorization. Contact the responsible party for details.

- To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication. Operating the device with the supplied antenna will ensure that this requirement is met.

- Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

13 MPE CONSIDERATIONS

References: 47 C.F.R. § 1.1310

Radiofrequency radiation exposure limits.

The criteria listed in table 1 shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in § 1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of § 2.1093 of this chapter. Further information on evaluating compliance with these limits can be found in the FCC's OST/OET Bulletin Number 65, "Evaluating Compliance with FCC-Specified Guidelines for Human Exposure to Radiofrequency Radiation."

Table 1—Limits for Maximum Permissible Exposure (MPE) **Frequency range (MHz)**	**Electric field strength (V/m)**	**Magnetic field strength (A/m)**	**Power density (mW/cm2)**	**Averaging time (minutes)**
(A) Limits for Occupational/Controlled Exposures				
0.3-3.0	614	1.63	*(100)	6
3.0-30	1842/f	4.89/f	*(900/f2)	6
30-300	61.4	0.163	1.0	6
300-1500			f/300	6
1500-100.000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*(180/f2)	30
30-300	27.5	0.073	0.2	30
300-1500			f/1500	30
1500-100.000			1.0	30
f = frequency in MHz				
* = Plane-wave equivalent power density				

Industry Canada Section 2.5.1 Exemption from Routine Evaluation Limits – SAR Evaluation

SAR evaluation is required if the separation distance between the user and the radiating element of the device is less than or equal to 20 cm, except when the device operates as follows:

From 3 kHz up to 1 GHz inclusively, and with output power (i.e. the higher of the conducted or equivalent isotropically radiated power (e.i.r.p.) source-based, time-averaged output power) that is less than or equal to 200 mW for general public use and 1000 mW for controlled use;

Prediction of MPE Limit for a Specified Distance

Reference: OET Bulletin 65, Edition 97-01

The power density formula is as follows:

$$S = \frac{PG}{4\pi R^2}$$

where: S = power density
P = power input to the antenna
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna

Maximum peak output power at antenna terminal:	7.30	(dBm)
Maximum peak output power at antenna terminal:	5.37	(mW)
Antenna Gain (typical):	-2.00	(dBi)
Maximum Antenna Gain:	0.63	(numeric)
Prediction Distance:	20.00	(cm)
Prediction Frequency:	915.49	(MHz)
MPE Limit for Uncontrolled Exposure at Prediction Frequency:	1.00	(mW/cm^2)
Power Density at the Prediction Frequency:	0.0007	(mW/cm^2)
Maximum Allowable Antenna Gain:	29.71	(dBi)
Margin of Compliance at 20 cm:	31.71	(dB)

The device meets the condition for an Industry Canada exemption from the routine evaluation limits because its transmit power of 5 mW is below the limit of 200 mW and the separation distance is greater than 20 cm.

ANNEX A NVLAP CERTIFICATE of ACCREDITATION

United States Department of Commerce
National Institute of Standards and Technology

NVLAP®

Certificate of Accreditation to ISO/IEC 17025:2005

NVLAP LAB CODE: 200125-0

Walshire Labs, LLC
Largo, FL

is accredited by the National Voluntary Laboratory Accreditation Program for specific services, listed on the Scope of Accreditation, for:

ELECTROMAGNETIC COMPATIBILITY AND TELECOMMUNICATIONS

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communique dated January 2009).

DEPARTMENT OF COMMERCE · UNITED STATES OF AMERICA

2012-04-01 through 2013-03-31
Effective dates

David F. Alderman
For the National Institute of Standards and Technology

NVLAP-01C (REV. 2009-01-28)

ANNEX B DISCLOSURE STATEMENT

Walshire Labs, LLC represents to the client that testing was done in accordance with standard procedures as applicable and that reported test results are accurate within generally accepted commercial ranges of accuracy. Walshire Labs Inc. test reports only apply to the specific sample(s) tested. This report is the property of the client. This report shall not be reproduced except in full without the expressed written approval of Walshire Labs, LLC.

TERMS and CONDITIONS

ARTICLE 1 *- Services, Walshire Labs will:*

1.1 Act for Client in a professional manner, using the degree of care and skill ordinarily exercised by and consistent with the standards of the profession.

1.2 Provide only those services that lie within the technical and professional area of expertise and capability of the Lab.

1.3 Perform all technical services in accordance with accepted laboratory test principles and practices.

1.4 Use test equipment which has been calibrated within a period not exceeding the manufacturer's recommendation and which is traceable to the NIST.

1.6 Consider all reports to be the confidential property of the client, and distribute reports only to those persons designated by the client.

ARTICLE 2 *- Client's Responsibilities, The Client will:*

2.1 Provide all information necessary for proper performance of technical services.

2.2 Designate a person who is authorized to transmit instructions, receive information and test data reports, interpret and define Client's policies, and make decisions regarding technical services, as may be required at Clients expense.

2.3 Deliver without cost, representative samples of product for technical evaluation, together with any relevant data.

2.4 Furnish such labor and equipment necessary to handle sample product and to facilitate the technical evaluation.

2.5 The Client shall provide prior to the start of evaluation testing a signed Purchase Order for the amount agreed to by both parties.

ARTICLE 3 *- General Requirements.*

3.1 The only warranty made by Walshire Labs, in connection with services performed thereunder is that it will use that degree of care and skill as stated in Article 1.1 and 1.3 above. No other warranty, expressed or implied, is made or intended for services provided thereunder.

3.2 Walshire Labs shall supply technical services and prepare reports based solely on product samples submitted. The Client understands that application of the data to other devices is highly speculative and should be applied with extreme caution.

3.3 Walshire Labs agrees to exercise ordinary care in receiving, preserving, and shipping any test sample to be tested, but assumes no responsibility for damages, either direct or consequential, which arise or are alleged to arise from loss, damage or destruction of the sample due to the act of examination, modification or testing, or technical analysis, or circumstances beyond our control.

3.4 The Client recognizes that generally accepted error variances apply and agrees to consider such error variances in its use of test data.

3.5 It is agreed between Walshire Labs and Client that no distribution of any test reports, etc. shall be made to any third party without the prior written consent of both parties.

3.6 Test Reports may not be used by the Client to claim product endorsement by NVLAP or any agency of the U.S. Government.

ARTICLE 4 *- Payment.*

4.1 The Client agrees to pay for services and expenses as covered in the Purchase Order or modified by Article 2.2. Walshire Labs will present an invoice at the completion of work and will be paid within 15 days of receipt by Client.